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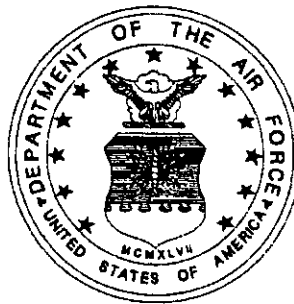
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United States Air Force

Environmental Restoration Program

Eielson Air Force Base, Alaska



**Sitewide Remedial Investigation/
Feasibility Study**

Volume 1: Remedial Investigation

FINAL

August 1995

[REDACTED]

United States Air Force

Environmental Restoration Program

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EXECUTIVE SUMMARY

This report presents the results of the sitewide remedial investigation (RI) conducted at Eielson Air Force Base (AFB), Alaska. Most of these data were previously presented in technical reports and used to support RIs at individual operable units (OUs), to provide input for the sitewide human health and biological risk assessments, and to develop, evaluate, and select remedial alternatives as part of the sitewide FS. This report is Volume 1 of a four volume sitewide RI and feasibility study (FS). The sitewide reports are as follows:

Volume 1:	Remedial Investigation
Volume 2:	Feasibility Study
Volume 3:	Baseline Risk Assessment
Volume 4:	Biological Risk Assessment.

The approach used at Eielson AFB was to define the nature and extent of contamination at each individual source area through OU investigations and source evaluation reports (SERs), and to evaluate cumulative environmental impacts through a sitewide investigation. The purpose of the sitewide investigation was two-fold: to collect information about site characteristics needed to support all environmental characterization and restoration efforts on the base, and to identify and characterize cumulative environmental impacts not addressed in the OU or SER investigations. The objectives for the sitewide investigation were as follows:

1. Provide information about site hydrogeology and background soil and groundwater characteristics to support individual OU RI/FS efforts and the sitewide RI/FS.
2. Identify and characterize contamination that is not confined or attributable to specific source areas through sitewide monitoring of groundwater and surface water.
3. Provide a mechanism for continued cohesive sitewide monitoring.
4. Evaluate cumulative risks to human health and the environment from contamination from multiple source areas through multiple pathways.

These objectives were addressed in studies carried out from 1991 to 1994. Results of the sitewide human health and ecological risk assessments are presented in Volumes 3 and 4 of the sitewide RI/FS.

The sitewide RI addressed background soil and groundwater quality, site hydrogeology, and surface water and sediment quality. In addition, sitewide groundwater monitoring was conducted from 1992 through 1994 to ensure that contaminant plumes identified in OU investigations were not spreading to previously uncontaminated areas, and that releases were not occurring in areas designated or recommended for no further action. The sitewide monitoring program also captured miscellaneous groundwater monitoring requirements across the base. The following field investigations were carried out as part of the sitewide RI: background soil sampling (1991), background groundwater sampling (1992 through 1994), sitewide groundwater monitoring (1992 through 1994), surface water and sediment sampling (1993 and 1994), and aquatic biota sampling (1994).

Background soil, groundwater, and hydrogeologic data were used to evaluate the nature, extent, and movement of contamination at various source areas across the base. Results of sitewide groundwater monitoring indicate that in general, contaminant plumes are not expanding, and levels are either constant or are decreasing (however, not all identified plumes were sampled under the sitewide program between 1992 and 1994). Monitoring results have also supported recommendations for no further action at some source areas, and no contaminants have been detected in shallow groundwater at the north (downgradient) edge of the base in the area of the North Boundary Wells. Surface water and sediment contamination is largely confined to Garrison Slough; only traces of contamination have been found in other surface water bodies (French Creek, Moose Creek, Piledriver Slough, Flightline Pond, and Lily Lake).

Based on 1993 and 1994 data, the water in Garrison Slough contains low concentrations of volatile organic compounds (VOCs) (less than 2 $\mu\text{g/L}$) and pesticides (less than 0.052 $\mu\text{g/L}$). Garrison Slough sediment is contaminated with pesticides (DDT, DDD, and DDE) at numerous locations along its entire length. The VOCs probably originate from contaminated groundwater discharging into the slough from adjacent source areas, and the pesticides were probably derived from the former widespread application of pesticides across the base.

Polychlorinated biphenyls (PCBs) were measured in Garrison Slough sediment from the area just upstream of Arctic Avenue to Transmitter Road (the most downstream station sampled). The maximum concentration of Aroclor 1260 in sediment was 55,000 $\mu\text{g/kg}$ dry weight. The PCB concentration dropped by an order of magnitude approximately 200 m downstream and by another order of magnitude approximately 700 m downstream. A point source of PCBs appears to exist in Garrison Slough south of Arctic Avenue near Building 2350. The PCBs could have been contained in a waste discharge or spill that directly entered the slough. Elevated PCB concentrations in sediment downstream of Building 2350 indicate that downstream migration of the PCBs has occurred, most likely by the erosion and transport of contaminated sediments.

Polynuclear aromatic hydrocarbons (PAHs), pesticides, and PCBs were detected in aquatic biota samples collected from Garrison Slough in 1994. A strong spatial relationship exists between PCB concentrations in sediment and fish; that is, the highest concentrations in sediment were measured in Garrison Slough near Arctic Avenue, and the highest concentrations in fish tissue were measured in fish caught in the same reach of the slough. Additionally, concentrations of PCBs in fish tissue decreased at points downstream of Arctic Avenue and were approaching background in tributary streams upstream of the Garrison Slough-Moose Creek confluence. Concentrations in both sediment and tissue were orders of magnitude lower at other sampling locations. Therefore, it is assumed that a complete exposure pathway exists from the sediment to the fish in lower Garrison Slough, and that the high concentrations in fish tissues are a direct result of exposure to the contaminated sediment.

Contaminant concentration data for surface water, sediment, and aquatic biota were used in the sitewide human health and biological risk assessments conducted by the U.S. Air Force to evaluate the nature and magnitude of risks to human health resulting from the contamination.

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LIST OF ACRONYMS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AFB	Air Force Base
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BES	(U.S. Air Force) Bioenvironmental Engineering Services
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	(EPA) Contract Laboratory Program
DCE	dichloroethene
DDD	2,2-bis(para-chlorophenyl)-1,1-dichloroethane
DDE	1,1'-(dichloroethenylidene)bis(4-chlorophenyl)
DDT	dichlorodiphenyltrichloroethane
DL	detection limit
DRO	diesel range organics
EPA	U. S. Environmental Protection Agency
FDA	Food and Drug Administration
FFA	Federal Facility Agreement
FNSB	Fairbanks North Star Borough
FR	Federal Register
FS	feasibility study
FSA	fuel saturated area
GC/ECD	gas chromatography/electron capture detection
GC/MS	gas chromatography/mass spectrometry
GRO	gasoline range organics
HLA	Harding Lawson Associates
HPLC	high performance liquid chromatography
IRP	(U.S. Air Force) Installation Restoration Program
LFI	limited field investigation
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
msl	mean sea level
MW	molecular weight
NCP	National Contingency Plan
NOAA	National Oceanographic and Atmospheric Administration
NPL	National Priorities List
OU	operable unit
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
POL	petroleum, oil, and lubricant
QC	quality control
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
SAIC	Science Applications International Corporation

SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SER	Source Evaluation Report
SIM	selected ion mode
SMCL	secondary maximum contaminant level
SOP	standard operating procedure
SVOC	semivolatile organic compound
SWMP	Sitewide Monitoring Program
TAP	Trans-Alaska pipeline
TBC	to be considered
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TOC	total organic carbon
TPH	total petroleum hydrocarbons
VOC	volatile organic compound
WTP	water treatment plant

1.0 INTRODUCTION

This report presents the results of the sitewide remedial investigation (RI) conducted at Eielson Air Force Base (AFB), Alaska. This investigation was conducted in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Contingency Plan (NCP), and the Federal Facility Agreement (FFA) for Eielson AFB. This report is Volume 1 of a four volume sitewide RI and feasibility study (FS). The sitewide reports are as follows:

Volume 1:	Remedial Investigation
Volume 2:	Feasibility Study
Volume 3:	Baseline Risk Assessment
Volume 4:	Biological Risk Assessment.

1.1 PURPOSE OF REPORT

The purpose of this report is to present data collected under the sitewide RI at Eielson AFB from 1991 to 1994, as well as historical data from the U.S. Air Force's Installation Restoration Program (IRP) investigations as applicable. Most of these data have been previously presented in technical reports and used to support RIs at individual operable units (OUs), to provide input for the sitewide human health and biological risk assessments, and to develop, evaluate, and select remedial alternatives as part of the sitewide FS.

1.2 REPORT ORGANIZATION

Section 1.0 of this report is an introduction; it provides background information and summarizes the nature and extent of source area contamination at Eielson AFB. Section 2.0 describes the objectives and scope of the sitewide investigation. Section 3.0 summarizes the setting and characteristics of Eielson AFB. Section 4.0 discusses the nature and extent of contamination identified in the sitewide investigation. Section 5.0 identifies potential applicable or relevant and appropriate requirements (ARARs) to be considered during the development and evaluation of sitewide remedial alternatives. Section 6.0 is a list of references cited in this report. Supporting data are provided in appendixes as follows:

- Appendix A--Automatic Water-Level Monitoring Data
- Appendix B--Manual Water-Level Monitoring Data
- Appendix C--Review of Hydraulic Test Data
- Appendix D--Hydraulic Test Data for Engineer Hill
- Appendix E--Background Soil Information
- Appendix F--Background Groundwater Data
- Appendix G--Sitewide Monitoring Groundwater Data
- Appendix H--Surface Water and Sediment Data
- Appendix I--Aquatic Biota Tissue Data.

1.3 SITE HISTORY

Eielson AFB is located in central Alaska, approximately 40 km southeast of Fairbanks, and 160 km south of the Arctic Circle (Figure 1.1). The base was originally constructed in 1943 and was used by the U.S. Army during World War II as a satellite installation of Ladd Field (now Fort Wainwright).

The base closed at the conclusion of the war, but reopened in 1947 after control was transferred from the U.S. Army to the U.S. Air Force. Major facility expansion occurred between 1947 and 1954. Additional base development and construction have continued through the years as Eielson AFB became an integral part of the Pacific Air Force that provides tactical support to the Alaska Air Command.

The base encompasses 8000 hectares containing aircraft runways, taxiways, aprons, hangars, maintenance facilities, communication facilities, munitions storage areas, administrative offices and support buildings, residential housing, schools, and community recreational facilities. Other facilities not contiguous with Eielson AFB are the Blair Lakes Target Facility, about 72 km southeast of Fairbanks and 56 km southwest of the primary base area, and the Birch Lake Recreation Area, about 48 km south of the base.

Over the years, some areas of the base have been contaminated by petroleum fuels and other hazardous materials. The base uses a variety of fuels (aviation gasoline, motor gasoline, diesel, JP-4), oils, lubricants, solvents, cleaners, paints, and pesticides in operational and maintenance activities. In the past, wastes from these activities were often burned, used for road oiling, discharged to surface pits, or placed in landfills on the base. These past activities have created areas of contamination that could be hazardous to human health or the environment.

To identify and evaluate potential problems from past activities at military installations, the Department of Defense established the IRP. The IRP consisted of four phases:

- Phase I--Records Search. Identify and set priorities for past disposal source areas containing contaminants that pose a hazard to public health or the environment either from migration to surface water or groundwater, or from persistence in the environment.
- Phase II--Confirmation and Quantification. Confirm the presence and extent of contamination, characterize the waste, and identify source areas where remedial action would be required in Phase IV.
- Phase III--Technology Development. Develop a sound database from which to prepare a comprehensive remedial action plan.
- Phase IV--Remedial Action Plan. Develop and implement the remedial action plan.

IRP implementation for Eielson AFB began in 1982. The initial records search identified 43 potential disposal or spill areas at Eielson AFB and recommended that confirmation studies be conducted on the basis of high migration potential (CH2M Hill 1982). These studies were followed by Phase II and IV investigations and feasibility studies, which concluded in 1991 (no Phase III studies were conducted). During the IRP investigations and as a result of construction activities, 21 contaminated areas were identified. A summary of IRP investigations and reports is provided in Table 1.1.

On November 21, 1989, the U.S. Environmental Protection Agency (EPA) added Eielson AFB to the National Priorities List (NPL) (54 FR 48184). The NPL designated the facility as a federal Superfund site subject to the remedial response requirements of the CERCLA, as amended by the 1986 *Superfund Amendments and Reauthorization Act* (SARA). RI and response activities at Eielson AFB must now fully comply with CERCLA requirements as outlined in the NCP (40 CFR 300.420). The

entire base, including Blair Lakes Target Facility and Birch Lake Recreation Area, is defined as the Superfund site.

On May 21, 1991, the U.S. Air Force, the EPA, and the Alaska Department of Environmental Conservation (ADEC) signed the FFA for Eielson AFB, which listed 64 potential source areas of contamination. The FFA established a procedure and schedule for developing, implementing, and monitoring appropriate response actions at the base in accordance with CERCLA, the NCP, Superfund guidance and policy, the *Resource Conservation and Recovery Act* (RCRA) guidance and policy, and applicable Alaska state law. Under the terms of the FFA, the environmental impacts associated with past and present on-base activities were investigated, and removal and/or remedial action will be taken to protect the public health and welfare, and the environment. The FFA also identifies the need for a sitewide RI/FS that integrates the findings and recommendations of sitewide investigations and assessments into a comprehensive Record of Decision (ROD).

Sixty of the 64 potential source areas listed in the FFA were identified for further analysis under CERCLA. The FFA grouped 26 of the source areas into six OUs to be evaluated under the RI/FS process. Seven additional source areas were assigned to an OU in 1994. The source areas were grouped based on similar source characteristics and not by physical location. The six OUs are as follows:

- OU-1--source areas contaminated with petroleum, some with recent evidence of floating product
- OU-2--source areas contaminated with petroleum, some with past but not recent evidence of floating product
- OU-3--source areas contaminated with solvents
- OU-4--source areas used for land disposal of sludge, drums and asphalt
- OU-5--source areas used for landfill activities
- OU-6--Ski Lodge well area contaminated with petroleum.

OUs 3, 4, and 5 were grouped together in the RI/FS process because they had the same FFA schedule. After the RI/FS reports for each OU are finalized, a ROD that documents the remedial actions (if any) to be taken at each source area is signed. The RODs for OUs 1, 2, and 6 were finalized in 1994, and the ROD for OUs 3, 4, and 5 is currently in preparation.

Thirty-four potential source areas listed in the FFA were not initially assigned to an OU. In the FFA, these areas were divided into two source evaluation report (SER) groups for Phase 1 or Phase 2 source evaluations. Phase 1 activities were limited to "desk-top" or historical data evaluation, comparable in scope to the preliminary assessment phase of a CERCLA investigation. Phase 2 activities required limited field investigations that provided additional data needed to fully evaluate the sites. The final source evaluation reports present one of the following recommendations for each potential source area evaluated: no further action, referral to another state or federal program, interim remedial or removal action, or assignment to an OU for RI/FS. The final disposition of each SER site will be documented in one of the RODs. Table 1.2 identifies each FFA source area and the OU or SER to which it belongs. Source area locations are shown in Figure 1.2.

1.4 NATURE AND EXTENT OF SOURCE AREA CONTAMINATION

The approach used at Eielson AFB was to define the nature and extent of contamination at each individual source area through an OU or SER investigation, and to evaluate cumulative environmental impacts in a sitewide investigation. Information collected on a source area basis was used to estimate the potential risks to human health and the environment from exposure to contamination, and the fate and transport of contaminants away from a given source area. Table 1.3 is a summary of the major source areas of contamination identified at Eielson AFB, the primary contaminants of concern (i.e., those that pose an unacceptable risk), and the known or suspected contaminant source. These source areas are primarily contaminated with fuel-related compounds (benzene, toluene, ethylbenzene, and xylenes [BTEX]) and solvents (trichloroethylene [TCE] and dichloroethylene [DCE]). Pesticide contamination was found in soil at source area SS35 in OU-4. At most of these areas, remedial action is required because of an unacceptable potential health risk from the unrestricted domestic use of groundwater. In most cases, contaminated soils do not directly pose an unacceptable risk through ingestion or dermal contact; however, the soil contaminants may be a source of continuing releases to groundwater, thereby contributing to risk. The potential risks to ecological receptors from individual source area contamination were within the acceptable range (USAF 1995e).

The lateral and vertical extent of groundwater contamination at Eielson AFB was delineated in the individual OU investigations (USAF 1993d, 1994b, 1995a; Engineering Science 1994). In several areas, plumes of contamination from different source areas have coalesced (ST10/ST14 in OU-2, ST13/DP26 in OU-2, and WP45/ST57 in OU-3). Benzene has been detected in one drinking water supply well on the base; this contaminant plume originated from source area ST48 in OU-1, and was drawn into Base Supply Well D by pumping (USAF 1994b). The plumes have either remained the same size or have diminished since the IRP investigations in the 1980s; none of the plumes appear to be spreading. The potential for plume migration is addressed in the OU RIs and baseline risk assessments.

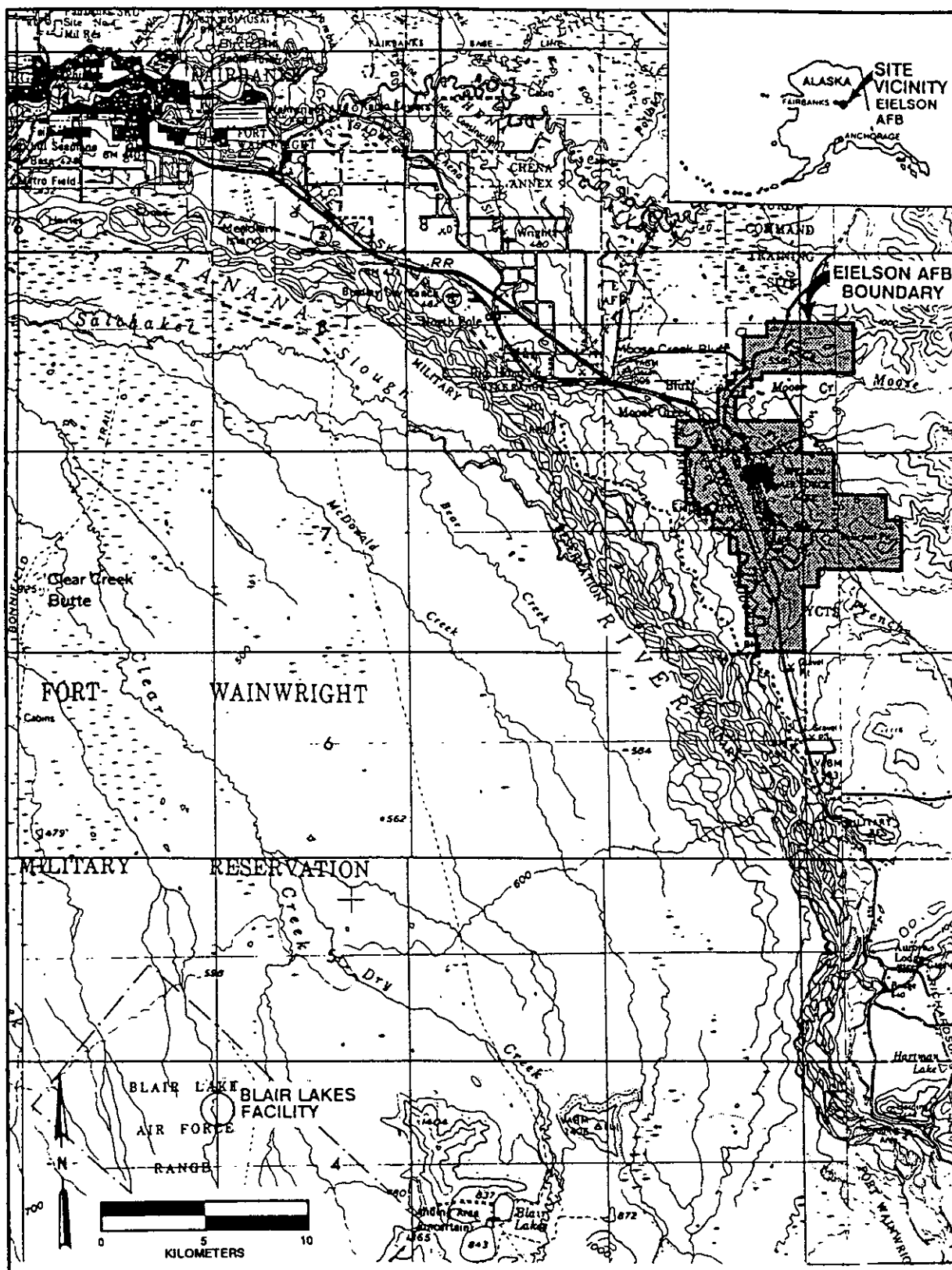


FIGURE 1.1. Site Location Map



TABLE 1.1. Summary of the IRP Investigations and Reports			
IRP	Author	Report and Information Obtained	Date
PHASE I	CH2M HILL	IRP Records Search: Detailed review of pertinent installation records, contacts with 15 gov't organizations, site reconnaissance, calculated Hazardous Assessment Rating on 43 source areas. Recommended 17 source areas for further investigation.	11-82
PHASE II	Dames and Moore	IRP Phase II Confirmation/Quantification Stage 1. First Draft Report: Sampled 17 recommended source areas. Recommended further action at the source areas to determine the extent of contamination.	2-85
	Dames and Moore	IRP Phase II Confirmation/Quantification Stage 2. Final Report: Sampled 3 source areas. Reported analytical results, significance of findings. Recommended further action at the source areas to determine the extent of contamination.	4-3-88
PHASE IV	Hazardous Material Technical Center	Statement of Work Phase IV-A Remedial Action Plan IRP: For 15 source areas in the fuel saturated area (FSA).	6-86
	SAIC	IRP Phase IV-A Remedial Action Plan. Draft Work Plan For Additional Data Collection: 12 source areas.	7-10-87
	SAIC	IRP Phase IV-A Remedial Action Plan. Preliminary Evaluation of Site Characterization Data: Site characterization and data gaps.	7-10-87
	SAIC	Identification and Labeling of Drummed Waste at Eielson AFB.	7-10-87
	SAIC	IRP Phase IV-A Remedial Action Plan. Work Plan For Completing RI/FS Activities: Field investigation, sampling, and remedial action alternatives.	8-18-87
	HLA	IRP Stage 3 Work Plan and RI: 24 source area results and significance of findings, risk assessment, and recommendations.	1-88
	SAIC	IRP RI/FS of the FSA. Draft Interim Report of RI: 12 source areas.	4-7-88
	SAIC	IRP RI/FS at Site 25, The Weathered Tank Sludge Burial Site: Results, nature and extent of contamination, baseline risk assessment, and remedial action recommendations.	2-15-88 11-16-88
RI/FS	SAIC	IRP RI/FS of the FSA. Draft RI Report: RI at 11 source areas. Presented results, nature and extent of contamination, baseline risk assessment, and recommendations.	2-6-89
	SAIC	IRP RI/FS of the FSA. Decision Document For Selected Sites: 4 source areas.	2-27-89
	SAIC	IRP Draft FS of the FSA. Initial Screening of Remedial Technologies and Process Options.	3-89
	SAIC	IRP Draft FS of FSA. Development and Evaluation of Alternatives	4-89
	SAIC	IRP Draft FS of FSA. Detailed Analysis of Alternatives.	5-89
	HLA	IRP Stage 4 Work Plan and RI: Samples 24 source areas and presented findings, risk assessment, and recommendations.	5-90
	Jacobs Engineering	IRP Draft Stage 4 Sampling Analysis Plan: Developed sampling plan and methodology for SERs.	3-91
	CH2M HILL	IRP Vehicle Maintenance Shop and Fuel Pipeline Report: Sampling and study.	7-91

TABLE 1.2. Source Area Descriptions

Source Area Designation	Source Area Name	Active Periods/Current Status	Wastes Received and Releases	Category
LF01	Original base landfill	1950 - 1960/inactive	General refuse including empty cans and 55-gallon drums; may have received waste oils, spent solvents, paint residues, and thinners	SER Phase 2
LF02	Old base landfill	1960 - 1967/inactive	General refuse; also received waste oils, spent solvents, paint residues and thinners	SER assigned to OU-5 in 1994
LF03	Current base landfill (inactive)	Landfill 1967 - 1987; Fire department training 1955 - 1976/inactive	General refuse; landfill received waste oils, spent solvents, paint residues and thinners, radioactive photographic chemicals; POL wastes burned during fire training	OU-5
LF04	Old Army landfill and EOD area	Unknown/active	General refuse and possibly small quantities of waste oil, spent solvents, munitions, and spent cartridges received by old landfill; current munitions disposal and explosives detonation area	OU-5
LF05	Old Army landfill	Unknown/inactive	General refuse including scrap materials and empty drums and containers; probably received small quantities of waste oils and spent solvents	SER Phase 1
LF06	Old landfill	1959 - 1963/inactive	Secondary landfill received general refuse, empty drums and paint containers; small quantities of waste paints, thinners, and spent solvents as drum residuals	SER assigned to OU-5 in 1994
LF07	Test landfill	1967/inactive	General household garbage	SER Phase 1
FT08	Fire training area (past)	1948 - 1955/inactive	Suspected fire training area; POL waste used in fire training exercises	SER Phase 1
FT09	Fire training area (present)	1976 - 1987/inactive	500 to 1,000 gallons of JP-4 fuel used during each exercise	OU-5
ST10	E-2 POL storage	Prior to 1978/active	Gasoline leaks from storage tanks at the E-2 POL storage area; possible migration to Spruce Lake	OU-2
ST11	Fuel-saturated area	1950s/inactive	Diesel fuel floating on water table; possibly released from tanks at former bakery or former boiler house	OU-2

TABLE 1.2. Source Area Descriptions

Source Area Designation	Source Area Name	Active Periods/Current Status	Wastes Received and Releases	Category
SS12	JP-4 spill, Building 2351	1981/inactive	JP-4 fuel spill; 5,000 gallons spilled, majority contained within building, 100 gallons flowed outside building	SER Phase 1
ST13	E-4 diesel fuel spill	Unknown/active	Diesel and gasoline from ruptured, leaking, or overfilled fuel bladders at E-4 refueling/defueling area	OU-2
SS14	E-2, RR JP-4 spill area	Prior to 1977/inactive	JP-4 fuel spills during delivery of fuels along railroad line adjacent to E-2 POL storage area	OU-2
ST15	Multiproduct fuel line	1970 and 1973/active	5,000-gallon spill of gasoline in 1970 and JP-4 fuel in 1973	SER Phase 1
ST16	MOGAS fuel line spill	Around 1957/inactive	MOGAS spill of 5,000 gallons	SER Phase 1
ST17	Canol pipeline spill	1957/inactive	Pipeline rupture released 20,000 gallons diesel fuel onto an adjacent highway	SER Phase 1
ST18	Oil boiler fuel-saturated area	Mid-1970s/inactive	Diesel fuel floating in 8-foot-deep holes dug during construction activities; possibly from old boiler plant	OU-2
ST19	JP-4 fuel line spill area	Late 1950s/inactive	JP-4 fuel release of 200,000 gallons during fuel line rupture	OU-2
ST20	Refueling loop fuel-saturated area	Unknown/active	JP-4 fuel spills in the refueling area; also leaks of JP-4 fuel from delivery lines from buried storage tanks	OU-1
SD21	Road oiling, Quarry Road	1950 - early 1980s/inactive	POL waste prior to 1978 included waste oils, contaminated fuels, and spent solvents; since 1978, primarily waste engine oils and contaminated diesel fuel	SER Phase 1
SD22	Road oiling, Industrial Drive	1950 - early 1980s/inactive	POL waste prior to 1978 included waste oils, contaminated fuels, and spent solvents; since 1978, primarily waste engine oils and contaminated diesel fuel	SER Phase 1
SD23	Road oiling, Manchu Road	1950 - early 1980s/inactive	POL waste prior to 1978 included waste oils, contaminated fuels, and spent solvents; since 1978, primarily waste engine oils and contaminated diesel fuel	SER Phase 1
SD24	Road oiling, Gravel Haul Road	1950 - early 1980s/inactive	POL waste prior to 1978 included waste oils, contaminated fuels, and spent solvents; since 1978, primarily waste engine oils and contaminated diesel fuel	SER Phase 1

TABLE 1.2. Source Area Descriptions

Source Area Designation	Source Area Name	Active Periods/Current Status	Wastes Received and Releases	Category
DP25	E-6 fuel tank sludge burial site	1955 - 1980/inactive	Fuel with significant lead concentrations in sludge from periodic fuel storage tank cleaning, buried in shallow trenches	OU-4
DP26	E-10 fuel tank sludge burial pit	1955 - 1980/inactive	Fuel in weathered sludge from periodic fuel storage tank cleaning, buried in pit	OU-2
ST27	E-11 fuel storage tank area	Prior to 1980/inactive	Weathered sludge, possibly containing lead, buried between fuel tanks at the E-11 fuel storage area	OU-4
DP28	Fly ash disposal	1972 to 1977/inactive	Temporary storage of fly ash from central heating and powerplant	SER Phase 1
DP29	Drum burial site	1965 - 1968/inactive	400 to 500 drums and residue containing asphalt emulsion, engine oils, and solvents; some full drums of asphalt emulsion	SER Phase 1
SS30	PCB storage area, Building 2339	Unknown/inactive	Formerly stored PCB-containing materials including out-of-service transformers and capacitors, and PCB-contaminated soil and liquid from cleanup of PCB spill	SER Phase 1
SS31	PCB storage area, Building 3424	Unknown/inactive	Formerly stored PCB-containing materials including out-of-service transformers and capacitors, and PCB-contaminated soil and liquid from cleanup of PCB spill	SER Phase 1
WP32	Sewage treatment plant spill	Since 1970/active	Ponds provide additional contact time for chlorination of primary treated effluent; also serve as diversion ponds for POL spills; major spill of unknown industrial chemical or solvent reported in 1975	SER Phase 2
WP33	Treated effluent infiltration pond	Since 1978/active	Infiltration pond receives treated effluent from wastewater treatment plant year-round	SER assigned to OU-4 in 1994
WP34	Sewage sludge drying beds	Since 1953/active	Discharge of digested sludge from industrial wastewater; may contain industrial contaminants such as heavy metals	(not FFA)
SS35	Asphalt mixing area	Early 1950s to late 1960s/inactive	Mixing area for asphalt and base for road oiling operation; commingled waste oils and solvents mixed with contaminated fuels; possible disposal of 200 empty asphalt drums at site	OU-4

TABLE 1.2. Source Area Descriptions

Source Area Designation	Source Area Name	Active Periods/Current Status	Wastes Received and Releases	Category
SS36	Drum storage site	Late 1960s to mid-1970s/inactive	Tar, asphalt emulsion, waste oils, and contaminated fuel used for road maintenance and road oiling southeast of Buildings 6213 and 6215; possibly leaks or spills from drums of waste oils, hydraulic fluid, diesel fuel, and other POLs stored at the site	OU-4
SS37	Drum storage, asphalt mixing area	Since mid-1970s/inactive	Mixing area for asphalt and staging area for road oiling; possible leaks from tank containing tar and asphalt emulsion, waste oils and contaminated fuel; drums of waste oil, diesel fuel, JP-4 and PD-680	OU-4
WP38	Ski lodge well contamination	Late 1950s to 1970/inactive	Area contains old fuel storage tank area; pit for disposal of contaminated fuel and sludge	OU-6
SS39	Asphalt lake	Late 1940s/inactive	Asphalt emulsion leaked from several hundred rusted drums over 1-acre area; drums and miscellaneous debris embedded in soft tar to depth of 6 to 12 inches	OU-4
DP40	Powerplant sludge pit	Unknown/inactive	Received residue from air scrubbers; periodically received small quantities of sludge from acid treatment and cleaning of boilers	SER Phase 1
SS41	Old auto hobby shop	Prior to 1982/inactive	Waste oil and contaminated fuel from 55-gallon drums; small quantities of industrial solvents	SER Phase 1
SS42	Miscellaneous storage and disposal area	1960s/inactive	Site used for burial of empty drums and containers; possibly small quantities of POL waste, including solvents, as residue in drums	SER Phase 1
LF43	Asbestos landfill	Since May 1982/active	Permitted site for disposal of construction rubble containing asbestos	(not FFA)
DP44	Battery shop leach field, building	Unknown/inactive	Battery shop solvents possibly drained to leach fields	OU-3
WP45	Photo lab, Building 1183	Unknown/inactive	Photo chemicals discharged to dry well; trichloroethene, benzene, and other solvents present in nearby groundwater	OU-3
SS46	KC-135 crash site, Gate 2	1962/inactive	KC-135 crash; fuel consumed in fire	(not FFA)

TABLE 1.2. Source Area Descriptions

Source Area Designation	Source Area Name	Active Periods/Current Status	Wastes Received and Releases	Category
SS47	Commissary parking lot fuel spill	Unknown/status unknown	Fuel-contaminated soil in parking lot found at a depth of 9 feet in 1987; parking lot covers 150,000 square feet	SER Phase 1
ST48	Powerplant fuel spill	Unknown/inactive	Gasoline and diesel possibly from abandoned 3-inch pipelines near the base powerplant	OU-1
ST49	Building 1300 LUST spill site	Unknown/active	Diesel fuel for generator discharged through floor drains in combat alert hangar complex to septic system leach field	OU-1
SS50	Blair Lakes vehicle maintenance	Unknown/inactive	Heating oil spill at storage tank, and abandoned buried fuel lines; near water supply well for Blair Lakes vehicle maintenance building	OU-1
SS51	Blair Lakes ditch	1986/inactive	Diesel fuel from unknown source floating as 1/2-inch layer in ditch	OU-1
SS52	Blair Lakes diesel spill	Unknown/inactive	Diesel fuel spill from failure of 1-1/4-inch pipe connecting main diesel fuel storage tanks to 550-gallon above-ground day tanks near vehicle maintenance building and generator facility	OU-1
SS53	Blair Lakes fuel spill	Unknown/inactive	Unknown quantity of helicopter fuel spilled on pad for shed that houses defueling pumping equipment	OU-1
DP54	Blair Lakes drum disposal site	Unknown/inactive	Full and partially full drums of unknown material buried west of main Blair Lakes facility	OU-1
DP55	Birch Lakes burial site	Unknown/inactive	General refuse and suspected drums of waste oil and other hazardous materials	SER Phase 2
ST56	Engineer Hill fuel spill	1990/inactive	Diesel spill of unknown quantity at boiler plant	SER assigned to OU-3 in 1994
SS57	Fire station parking lot	Unknown/inactive	Unknown	OU-3
1ST58	Old QM service station	Unknown/inactive	Possible releases from above-ground tanks	SER assigned to OU-4 in 1994
ST59	Dining hall	Unknown/inactive	Diesel spill; contaminated soil has been removed	(not FFA)

TABLE 1.2. Source Area Descriptions

Source Area Designation	Source Area Name	Active Periods/Current Status	Wastes Received and Releases	Category
WP60	New auto hobby shop	Unknown/active	Water from oil/water separator drains to leach field; oils overwhelm leach field	SER Phase 1
SS61	Vehicle maintenance, Building 3213	Unknown/active	Oil from oil/water separator is released to leach field	SER assigned to OU-4 in 1994
SS62	Garrison Slough	Not applicable	Possibly contaminated groundwater and surface runoff from site	SER assigned to Site-wide
SS63	Asphalt Lake spill site	Unknown/inactive	Suspected pesticide spill; DDT, DDE, DDD found in soil	OU-4
SS64	Trans maintenance spill site	Unknown/inactive	Former staging area for hazardous materials	SER assigned to OU-4 in 1994

TABLE 1.3. Summary of Major Areas of Contamination Identified at Eielson AFB				
Operable Unit, Source Area	Major Contaminants	Affected Media	Description	Known or Suspected Source
OU-1, ST20	BTEX (floating fuel)	Groundwater Soils	E-7 Complex	Subsurface leak in JP-4 fuel supply line
	BTEX	Groundwater Soils	E-8 Complex	Surface spills of JP-4 fuel from overflowing storage tanks
	BTEX (floating fuel)	Groundwater Soils	E-9 Complex	Subsurface leaks from JP-4 fuel pipelines and tanks
OU-1, ST48	BTEX (floating fuel)	Groundwater Soils	Intersection of Industrial Dr. and Division St.	Leakage from abandoned fuel lines
OU-1, SS50/SS51/SS52	BTEX (floating fuel)	Groundwater Soils	Blair Lakes	Fuel spills
OU-2, ST10/SS14	BTEX, naphthalenes, total lead (floating fuel)	Groundwater Soils	From tank farm to Spruce (formerly Hardfill) Lake at ST10, from truck fueling station to the lake at SS14	Leaks from storage tanks and piping at ST10, leaks from fuel lines and surface spills at ST14
	Benzene, naphthalenes	Soils		
OU-2, ST13/DP26	BTEX, naphthalenes, total lead (floating fuel)	Groundwater	South end of flightline, east side	Rupture or overflow of fuel bladders, and leaks/spills from underground storage tanks and fuel outlets at ST13; leaks and spills from Tank 300 at DP26
	BTEX, naphthalenes	Soils		
OU-3, DP44	BTEX, TCE, DCE	Groundwater Soils	Battery shop leach field, near Large Aircraft Maintenance Hangar	Suspected sources are dry well in Building 1134 and jet engine maintenance activities in large aircraft maintenance hangar
OU-3, WP45/SS57	TCE, DCE, BTEX	Groundwater Soils	Photo lab/fire station parking lot	Suspected sources include old maintenance shop at SS57, dry well at WP45
OU-3, SS61	BTEX, TCE, DCE	Groundwater Soils	Vehicle Maintenance Building 3213	Dry wells on south side of building
OU-4, DP25	BTEX lead	Groundwater Soils	E-6 Fuel Storage Tank Area	Leaks in storage tanks and associated piping

TABLE 1.3. Summary of Major Areas of Contamination Identified at Eielson AFB				
Operable Unit, Source Area	Major Contaminants	Affected Media	Description	Known or Suspected Source
OU-4, SS35	DDT, DDD, DDE	Soils	Adjacent to Water Treatment Plant Pond	Not known
OU-4, ST58	BTEX	Groundwater Soils	Site of Old Quartermaster Service Station	Fuel spills and leaks from piping and tanks
OU-5, LF03/FT09	BTEX, TCE, DCE	Groundwater	Inactive base landfill and fire training area	Landfill debris, past fire training practices
	PAHs	Soil	Fire training area	Past fire training practices

2.0 SITEWIDE INVESTIGATION

As described in Section 1.4, the approach used at Eielson AFB was to define the nature and extent of contamination at each individual source area through OU and SER investigations, and to evaluate cumulative environmental impacts through a sitewide investigation. The purpose of the sitewide investigation was two-fold: to collect information about site characteristics needed to support all environmental characterization and restoration efforts on the base, and to identify and characterize cumulative environmental impacts not addressed in the OU or SER investigations.

2.1 SITEWIDE RI OBJECTIVES

The scope of the sitewide investigation was determined by identifying data gaps not addressed by source area investigations. These data gaps included insufficient information about background soil and groundwater quality, site hydrogeology, and surface water and sediment quality. An evaluation of the cumulative risks to human health and the environment from contaminants from multiple source areas through multiple pathways was also needed. In addition, although the nature and extent of groundwater contamination was fully delineated in the OU RIs, sitewide groundwater monitoring was needed to ensure that contaminant plumes were not spreading to previously uncontaminated areas and that releases were not occurring in areas designated or recommended for no further action. A sitewide program was also needed to capture the miscellaneous groundwater monitoring requirements across the base. Additional information about soil and air quality were not needed on a sitewide basis because soil contamination was adequately characterized in the OU RIs, and the OU baseline risk assessments indicated that the risk from airborne contaminants was extremely low (i.e., an excess cancer risk of less than 10^{-5}). Based on the data needs identified above, the following objectives for the sitewide investigation were formulated:

1. Provide information about site hydrogeology and background soil and groundwater characteristics to support individual OU RI/FS efforts and the sitewide RI/FS.
2. Identify and characterize contamination that is not confined or attributable to specific source areas through sitewide monitoring of groundwater and surface water.
3. Provide a mechanism for continued cohesive sitewide monitoring.
4. Evaluate cumulative risks to human health and the environment from contamination from multiple source areas through multiple pathways.

These objectives were addressed in sitewide studies carried out from 1991 to 1994. These studies were outlined in the *Site Management Plan for Eielson Air Force Base* (USAF 1993f).

2.2 CONTAMINANTS OF CONCERN

Table 2.1 summarizes the media and contaminants of concern addressed in the sitewide investigation. The contaminants of concern for each medium were identified by reviewing the results of previous IRP and CERCLA investigations. Contaminants that had not been previously identified were not included in the sitewide investigation sampling programs. Additional rationale for the selection of analytical parameters is provided in the following descriptions of sitewide field and analytical programs. Table 2.2 summarizes the sampling and analysis programs carried out under the sitewide investigation.

2.3 HYDROGEOLOGIC INVESTIGATIONS

Hydrogeologic investigations at Eielson AFB included the collection and analysis of manual and automatic water-level data and the evaluation of hydraulic test data. Automatic water-level monitoring equipment comprising data loggers and pressure transducers was installed at selected wells in September 1991 to support the OU-2 RI. They were initially installed at wells in source areas ST10, ST11, ST13, ST18, ST19, DP26, and ST48. Some of the equipment was later relocated to provide long-term monitoring at other source areas and to assess sitewide water-level changes. Table 2.3 provides information on the locations and dates of use for the automatic water-level monitoring equipment. The locations of wells containing the monitoring equipment are shown in Figure 2.1. Objectives of automatic water-level monitoring were as follows:

- Determine seasonal variations in groundwater levels.
- Monitor the effect of recharge events (rainfall and snowmelt).
- Determine the influence of pumping base water supply wells.
- Assess the influence of Garrison Slough.
- Provide information about horizontal and vertical hydraulic gradients.

Manual water-level measurements were collected from selected groundwater monitoring wells and staff gage locations on a monthly basis from September 1991 to August 1992, and less frequently thereafter. These data were used to prepare monthly sitewide water table elevation maps. Additional measurements were taken in May 1994 to clarify ground and surface water interactions in Garrison Slough north of the water treatment plant.

Hydraulic tests were performed during the IRP to provide estimates of aquifer parameters. The data from these tests were evaluated, and in some cases reanalyzed, to determine hydraulic conductivity and specific yield for the aquifer. The data from 2 multiple-well pumping tests and 30 slug tests were reviewed. One slug test was conducted on a well in the upland bedrock aquifer. All other tests were conducted on wells in the alluvial aquifer. The results of hydrogeologic investigations are provided in Section 3.4.

2.4 BACKGROUND SOIL SAMPLING

Background soil samples were collected at Eielson AFB during August and September 1991 as part of the OU-2 RI field effort. Background soils data for organic and inorganic constituents were needed to compare with sample results from areas of potential contamination. Constituents of concern identified in soil at Eielson AFB were primarily petroleum, oil, and lubricant (POL) products, spent solvents, and pesticides. Other potential contaminants of concern were polychlorinated biphenyls (PCBs) and heavy metals.

A literature search for background data at on-base and off-base locations was conducted prior to background soil sampling to minimize redundant sampling and analysis. In addition, soil survey information for Eielson AFB was reviewed and summarized as part of the background sampling effort.

Samples were collected from the three major soil types identified at the base: sand and gravel fill, fine-grained fluvial soils, and loess (fine-grained upland soil). Sand and gravel fill was widely used during construction of the developed portion of the base. Fluvial soil samples represented the original floodplain sediments in the lowland part of the base, and the loess samples represented the windblown silt deposits that blanket the upland portion of the base. Samples were collected away from areas of known or suspected contamination. Background soil sampling locations are shown in Figure 2.1.

Twenty-one samples of sand and gravel fill were collected from four borrow pits adjacent to the base: 28-Mile Pit, Mullins gravel pit, Grayling Lake, and Twin Lake. The material in these pits is similar to the sand and gravel fill used for base construction. Sixty samples of fine-grained fluvial sediment (30 surface and 30 subsurface) were collected adjacent to the Golden Valley Electric power line corridor southeast of the refueling loop. Surface samples were collected at a depth of 15 cm, and subsurface samples were collected at a depth of about 1 m below land surface. Ten samples of loess from upland areas were collected adjacent to the road to the Ski Lodge.

Soil samples were analyzed for metals, total petroleum hydrocarbons (TPH), pesticides, and PCBs (Table 2.2). TPH data were needed to ensure that background samples were not contaminated with petroleum products. Pesticides and herbicides are commonly used at Eielson AFB to control insects, rodents, and weeds (CH2M Hill 1982). Background data provided an estimate of ubiquitous concentrations of these constituents. Analytical data for metals were validated following EPA's *Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA 1988a).

Sample results for each soil type were tabulated, and the mean and standard deviation for each constituent were calculated. If a constituent was not detected in a sample, a value of one-half of the detection limit was included in the calculation of the mean and standard deviation. In addition, the 95% upper confidence limit on the mean background concentration was calculated using the following formula:

$$UCL = \bar{x} + t \left[\frac{\sigma}{\sqrt{n}} \right]$$

where <i>UCL</i>	=	upper confidence limit on the sample mean
\bar{x}	=	sample mean
<i>t</i>	=	<i>t</i> -value at an uncertainty of 5% and (<i>n</i> -1) degrees of freedom
σ	=	sample standard deviation
<i>n</i>	=	number of samples.

The upper confidence limit represents, with 95% confidence, the upper limit of the mean background concentration of that parameter in soil at Eielson AFB (assuming that representative samples were collected). The results of the background soil sampling are discussed in Section 3.5.

2.5 GROUNDWATER SAMPLING

Groundwater sampling was conducted at Eielson AFB from 1992 through 1994 under the Sitewide Monitoring Program (SWMP). The scope and objectives of the SWMP varied from year to year as wells or surface water locations were added or removed from the program. However, the specific

objectives in a given year fell under the broad sitewide RI objectives listed in Section 2.0. The SWMP was initiated in 1992 with the collection of groundwater samples from background wells and from the North Boundary Wells, which are located at the downgradient (northern) edge of the developed portion of the base. In 1993 and 1994, the program was expanded to include selected wells from OU source areas, SER sites, and surface water locations. This program will continue on annual basis throughout the environmental restoration process.

The results of the SWMP were initially presented in annual technical reports (see Section 2.8). The scope of the SWMP from 1992 to 1994 is described in the following sections. Sampling objectives, locations, and analytical parameters are summarized in Table 2.2, and well locations are shown in Figures 2.2 through 2.5 (background wells are shown in Figure 2.1). Each year, all sample results and associated quality control (QC) data were reviewed in accordance with EPA's laboratory data validation functional guidelines for evaluating inorganic and organic analyses (EPA 1988a, 1988b) to ensure that data quality objectives were met. Sample results were qualified as required.

2.5.1 1992 Sitewide Monitoring

In 1992, the SWMP objectives were as follows:

- Establish background groundwater quality.
- Monitor shallow groundwater quality at the downgradient (northern) edge of the base.

Samples were collected from background wells in June 1992 and from the North Boundary Wells in August 1992.

Background Wells. Sampling to establish background groundwater quality at Eielson AFB was conducted in June 1992. Background sampling was intended to fill gaps in existing regional groundwater quality information, which were either incomplete or not comparable to data collected at Eielson. Sampling was conducted in accordance with *Background Groundwater Quality Sampling and Analysis Plan* (USAF 1992a). The objectives of the program were to 1) collect background data that were directly comparable to sample results from OU and SER sites, and 2) evaluate major groundwater chemistry at the base. Existing data on groundwater flow and quality were reviewed to select appropriate background wells. Wells that were located hydraulically upgradient or cross-gradient from known sources of contamination and in areas where no contamination had been detected were selected for background monitoring. Background samples were collected from 17 monitoring wells. Sixteen of the wells were located in the alluvial floodplain (lowland) area of the base, and one was located in the upland area. No upgradient or cross-gradient wells were located in the upland area; however, one well was sampled to provide an estimate of the differences between the lowland and upland areas. This well (Well 38M03) was downgradient of a fuel-contaminated area on the ski hill. Samples were also collected from three nested wells at source area ST48 (shallow, intermediate, and deep) to evaluate vertical changes in groundwater chemistry.

The 1992 background groundwater samples were analyzed for total and dissolved metals, major anions, total organic carbon (TOC), alkalinity, total dissolved solids (TDS), and TPH (Table 2.2). Background metals data were needed to compare with concentrations measured in potentially contaminated areas of the base. TPH data were collected to ensure that background samples were not contaminated with fuel-related products. Organic compounds (i.e., volatile organic compounds [VOCs], pesticides, and PCBs) were not analyzed because background concentrations of these

compounds were assumed to be zero. The remaining analytes (anions, TOC, alkalinity, and TDS) were measured to characterize major groundwater geochemistry.

A statistical approach was used to estimate the mean ambient concentration of each constituent in groundwater. Analytical data were tabulated, and the mean and standard deviation for each constituent were calculated. If a constituent was not detected in a sample, a value of one-half of the detection limit for the analysis was included in the calculation of the mean and standard deviation. The upper confidence limit on the mean background concentration for each constituent was calculated using the formula presented in Section 2.4. The upper confidence limit represents, with 95% confidence, the upper limit of the mean background concentration of that parameter in groundwater at Eielson AFB (assuming that representative samples were collected).

Data were also used to evaluate major groundwater chemistry. The major cation and anion data were plotted on a trilinear diagram, and Stiff diagrams of data from selected samples were generated. These diagrams were used to identify water types and to evaluate similarities and differences in groundwater chemistry at different sites or at different depths within the aquifer.

North Boundary Wells. The North Boundary Wells are located at the north end of the base between the Richardson Highway and French Creek (Figure 2.2). Samples were collected from five North Boundary Wells in August 1992 to monitor the quality of shallow groundwater at the downgradient edge of base (wells 08M01, 51MB1, 51MB3, 51MB4, and 51MB5). The total depth and depth to groundwater in August 1992 for these wells are identified in Table 2.4. These wells were installed during the IRP in 1988 to assess the potential for offsite migration of contaminants in groundwater. However, their location and depth are not appropriate for accomplishing this objective because they do not span the entire downgradient edge of the base, and they are screened in only the shallowest portion of the aquifer. Under the CERCLA program at Eielson AFB, the migration of contaminants in groundwater was addressed in the OU RIs and baseline risk assessments. These studies demonstrated that contaminants of concern in groundwater are not migrating offsite (USAF 1993d, 1994b, 1995a; Engineering Science 1994). Although there is no evidence that groundwater contamination is migrating offsite, the North Boundary Wells were sampled to provide additional information about shallow groundwater quality at the downgradient edge of the base.

The sampling approach and methods were specified in the *Sampling and Analysis Plan for the North Boundary Wells* (USAF 1992b). Well 08M01, which is located near SER site FT08, was substituted for North Boundary Well 51MB2 when this well could not be located. However, Well 51MB2 was located in 1994 (but not sampled) and appears to be intact. North Boundary Wells were sampled for metals, VOCs, and TPH (Table 2.2) because the contaminants of concern identified in groundwater elsewhere at Eielson AFB are primarily fuel-related compounds, solvents, and lead. Pesticides, PCBs, and semivolatile organic compounds were not analyzed because they are not contaminants of concern in groundwater at Eielson AFB (with the exception of naphthalenes in several source areas).

2.5.2 1993 Sitewide Monitoring

The scope and approach of the 1993 sitewide groundwater monitoring were documented in the *1993 Sitewide Groundwater Monitoring Work Plan* (USAF 1993e). The 1993 SWMP objectives were as follows:

- Measure background concentrations of metals to evaluate seasonal variations in constituent concentrations.

- Sample the North Boundary Wells to monitor shallow groundwater quality at the downgradient edge of the base.
- Collect information from OU-2 source areas to support the Proposed Plan for remedial action.
- Collect additional information from source area LF03 to support the OU-5 RI.
- Collect additional information from three SER sites (LF05, LF06, and SS47) to support recommendations for no further action.

Objectives, sampling locations, and analytical parameters are identified in Table 2.2. Well locations are shown in Figures 2.1 through 2.4.

Background Wells. Background groundwater samples were collected from 16 background monitoring wells in June and August 1993 to evaluate seasonal variations in constituent concentrations. The wells were all located in the lowland area of the base and were the same background wells that were sampled in 1992. The upland well was not resampled because there were not enough upland background wells to provide a statistically significant assessment of background conditions. The samples were analyzed for metals and VOCs (Table 2.2). Samples were analyzed for VOCs because this analysis was not performed on the 1992 background samples.

Background metals data were evaluated to determine whether mean constituent concentrations were significantly different in August 1993 than in June 1993. August 1993 results were also compared with June 1992 data. Analytical results were compared using a *t*-test for data arranged in pairs because the same set of wells was sampled in two seasons. The null hypothesis of the statistical test is that the mean of the differences between the June and August measurements is zero. The alternative hypothesis is that the mean of the differences between the two measurements is not zero. The test statistic was computed using the following equation (from Sachs 1984) :

$$\hat{t} = \frac{(\sum d_i) / n}{\sqrt{\frac{\sum d_i^2 - (\sum d_i)^2 / n}{n(n-1)}}$$

where \hat{t} = test statistic
 d_i = difference between pairs of measurements
 n = number of sample pairs.

The test assumes that the differences between the June and August measurements are normally distributed. If an analyte was not detected in a sample, a value of one-half the detection limit was used in the calculation of the difference between two measurements. The critical *t*-value was obtained from a statistics table assuming 15 degrees of freedom (number of sample pairs minus one), desired level of uncertainty (5%), and type of test (two-sided).

The June and August 1993 background values for metals were combined with 1992 background data, and the mean, standard deviation, and 95% upper confidence limit on the mean background

concentration for each constituent was calculated. If a constituent was not detected in the sample, a value of one-half the detection limit was used in the calculation of the mean and standard deviation. The upper confidence limit was calculated using the equation presented in Section 2.4.

North Boundary Wells. Samples were collected from five North Boundary Wells in August 1993 to continue to monitor the quality of shallow groundwater at the downgradient edge of the base. North Boundary Well samples were analyzed for metals, VOCs, and diesel range organics (DRO), which are the same constituents that were analyzed in 1992 (Table 2.2). The DRO analysis (Method AK102) replaced the TPH analysis (Method 418.1) for fuel-related compounds.

OU Wells. Samples were collected from four source areas in OU-2 (ST11, ST18, ST19, and DP26) to provide additional data for the Proposed Plan for remedial action (Table 2.2). In 1991, arsenic was detected at concentrations above the federal and state maximum contaminant level (MCL) of 50 µg/L in groundwater samples from source areas ST11 and ST18 (USAF 1993d). Samples were collected from wells at ST11 and ST18 in June and August 1993 to confirm the 1991 arsenic values and to provide data that were directly comparable to background values. Samples from ST11 and ST18 were also analyzed for VOCs to confirm that fuel-related compounds were not present at concentrations above the trace levels measured in 1991.

Contaminant concentration data from source area ST19 were needed to refine fate and transport modeling results. A downgradient well (Well 19MW06) was also sampled to monitor the migration of fuel-related compounds in groundwater from source area ST19.

Floating petroleum product is present on the water table at source area DP26. Monitoring wells near the source of contamination and at the lateral and distal edges of a plume of groundwater contamination were sampled to monitor BTEX concentrations.

Samples were collected from one well in source area LF03 to support the OU-5 RI. Well 03M01 was sampled in June and August 1993 to confirm that high concentrations of metals and arsenic measured in 1988 (HLA 1989) decreased to background levels by 1992 (USAF 1995a).

The 1993 Work Plan identified two wells in OU-6 that were to be sampled as part of the OU-6 RI. These wells were removed from the SWMP prior to the August sampling event.

SER Wells. Four wells from SER source areas LF05 (Landfill 5), LF06 (Landfill 06), and SS47 (commissary parking lot) were added to the SWMP prior the August 1993 sampling event to support possible recommendations for no further action at those areas (Table 2.2). Samples from source areas LF05 and LF06 were analyzed for VOCs, semivolatile organic compounds (SVOCs), chlorinated pesticides, PCBs, and metals. Source area SS47 was the site of a former fuel spill; the groundwater samples were analyzed for VOCs, SVOCs, and lead.

2.5.3 1994 Sitewide Monitoring

The methods and approach used for sitewide monitoring in 1994 are specified in the *1994 Sitewide Monitoring Program Sampling and Analysis Plan* (USAF 1994a), and a work plan addendum prepared in September 1994. The objectives of the 1994 SWMP were as follows:

- Monitor background concentrations of metals in groundwater.
- Sample the North Boundary Wells to monitor shallow groundwater quality at the downgradient edge of the base.
- Collect information from OU-1 and OU-6 source areas to support the Proposed Plans for remedial action.
- Monitor OU-2 source areas in compliance with the requirements of the ROD.
- Collect additional information from selected source areas in OUs 3, 4, and 5 to support the RI/FS.
- Monitor selected SER sites to support decisions or recommendations for no further action.
- Collect data to complete the characterization of surface water and sediment quality; specifically, to confirm 1993 pesticide and PCB data from Garrison Slough and 1993 pesticide data from French Creek, and to identify and delineate a PCB hotspot in Garrison Slough sediments.
- Measure VOC concentrations in Garrison Slough to monitor the impact of adjacent source areas.

Objectives, sampling locations, and analytical parameters are identified in Table 2.2. Well locations are shown in Figures 2.1 through 2.5.

Background Wells. Eight background monitoring wells were sampled and analyzed for metals to provide data that were directly comparable to 1994 results from OU and SER wells and the North Boundary Wells (Table 2.2). The 1994 background data for metals were also combined with background data from previous years, and the mean, standard deviation, and upper confidence limit on the mean value for each constituent were recalculated.

North Boundary Wells. As in previous years, five North Boundary Wells were sampled for metals, VOCs, and DRO to continue to monitor the quality of shallow groundwater at the downgradient edge of the base. One well (Well 08M01) was resampled in September 1994 to confirm the presence of three VOCs detected in the August 1994 sample.

OU-1 Wells. Three wells from OU-1 were sampled to monitor contaminant concentrations at two source areas during the remedial design/remedial action phase of the Superfund response. Samples were collected from monitoring wells 48M04, 48M05, and 48M06 (shallow, intermediate, and deep) at source area ST48 to monitor groundwater quality adjacent to the primary base water supply well (Base Supply Well D), where benzene has been periodically detected. One sample was collected from Well 49M05 at source area ST49, because benzene was detected above the MCL of 5 µg/L in this well in 1993 (USAF 1994b). This sample was analyzed for BTEX.

OU-2 Wells. Samples were collected from selected wells at source areas ST10, ST11, ST18, ST19, and DP26 in accordance with the requirements of the OU-2 ROD. At ST10, a plume of benzene-contaminated groundwater originating from a fuel storage area and intersecting Spruce (formerly Hardfill) Lake was delineated in 1991 (USAF 1993d). The downgradient extent of this plume has not been established. A new well downgradient of Spruce Lake was to be sampled for fuel-related

compounds (BTEX) to assess whether contamination from ST10 had migrated downgradient of the lake. The new well was sampled by Air Force personnel in February 1995.

The OU-2 RI results indicated that no organic compounds were present at concentrations above risk-based levels of concern in groundwater at ST11 and ST18. One well at each of these source areas was sampled for VOCs to confirm that levels of contamination are decreasing.

At source area ST19, benzene and toluene were detected above risk-based levels of concern in a sample from Well 19-2A in 1991. Benzene concentrations in samples from this well had been decreasing since 1986 (USAF 1993d). Samples were collected from a new well installed near damaged Well 19-2A to confirm decreasing benzene concentrations. This new well was sampled in February 1995 by Air Force personnel. A sample was also collected from downgradient Well 19MW06 to assess whether contamination is migrating from ST19.

At source area DP26, two samples were collected and analyzed for BTEX to monitor the extent of a plume of benzene-contaminated groundwater. One sample was collected from a new well installed at the downgradient edge of the plume (Well 26MW19), and one from the lateral edge of the plume (Well 26-6). Well 26MW19 was sampled in February 1995 by Air Force personnel; two other new wells at the downgradient edge of the plume (wells 26MW17 and 26MW18) were not sampled.

OUs 3, 4, 5 Wells. OUs 3, 4, and 5 were grouped together in the RI process because they have the same FFA schedules. Samples were collected from ST27, SS36, SS39/SS63, and LF04 under the 1994 SWMP to verify that these source areas require no further action. Two wells from WP45 were also sampled. Four other OUs 3, 4, and 5 source areas were sampled under a separate work plan to provide additional site characterization data for the RI.

In the 1994 SWMP, two wells from WP45 were sampled to provide additional data for a natural attenuation study. Well 45M04 is located on the downgradient edge of a TCE and DCE plume. Well 45M07 is on the lateral edge of the plume, and is also downgradient of BTEX-contaminated groundwater collected from a soil boring at ST57 in 1992. Benzene was detected above the MCL of 5 $\mu\text{g/L}$ in a sample from 45M07 in 1992 (USAF 1995a).

POL contamination was not detected in groundwater at ST27 in 1992 (USAF 1995a). Lead was detected in samples from many wells, with a maximum of 120 $\mu\text{g/L}$ in a June 1992 sample from Well B-13. Samples were collected from wells B-8, B-11, and B-19 to confirm the absence of POL contamination and to monitor lead concentrations. Well B-13 was not sampled because it was damaged.

Groundwater contamination at SS36 was not identified in 1992, although lead was detected above 15 $\mu\text{g/L}$ in one groundwater probe sample (USAF 1995a). Samples from three wells were collected and analyzed for VOCs and metals (including lead) to verify the absence of contamination.

Total petroleum hydrocarbons, diesel/kerosene, and PAHs were detected in soils at SS39/SS63 (Asphalt Lake) in 1992; however, no groundwater contamination was identified at the time (USAF 1995a). Samples were collected from five wells and analyzed for fuel-related compounds to verify the absence of fuel-related groundwater contamination.

Samples were collected from all viable wells at LF04 in OU-5 to confirm the absence of organic contamination and to monitor metals concentrations.

OU-6 Wells. OU-6 consists of a single source area, the ski lodge (WP38). Leaking fuel storage tanks resulted in the contamination of groundwater in the bedrock aquifer on the ski hill. The OU-6 ROD was signed in September 1994. Quarterly monitoring for 1 year is required for OU-6, with the first sampling event occurring in August 1994. Seven wells were sampled for BTEX and metals to assess whether contaminated groundwater is migrating from the upland to the lowland area of the base.

SER Wells. Samples were collected from five SER sites as part of the SWMP. Two of these sites (LF01 and DP55) underwent a limited field investigation (LFI) in 1993. Results are reported in *Source Evaluation Report, Phase 2 Investigation, Limited Field Investigation* (USAF 1994d). The other three sites (LF05, ST16, and SS47) were assessed in *Source Evaluation Report, Phase I, Final* (USAF 1993i). The 1994 SWMP sampling objectives for SER sites are summarized below.

Groundwater contamination was not identified at LF01 (Landfill 01) during the LFI. One groundwater sample was collected in 1994 and analyzed for metals to monitor water quality downgradient of the landfill.

SER site DP55 (Birch Lake Recreation Area) has been recommended for no further action. One sample from the drinking water well was collected and analyzed for metals and VOCs to verify the absence of contamination.

LF05 (Landfill 05) has been recommended for no further action. One sample was collected from Well 05M01 and analyzed for metals because lead exceeded 15 $\mu\text{g/L}$ in a 1988 sample collected from this well. Lead was not detected in a 1993 sample from this well (USAF 1993g).

Source area ST16 has been recommended for no further action. One groundwater sample was collected and analyzed for VOCs to verify the absence of fuel-related contamination.

Lead was detected above 15 $\mu\text{g/L}$ in groundwater samples collected at SS47 (commissary parking lot) in 1988 (HLA 1989). Elevated lead was not confirmed in a sample collected from Well 47M05 in 1993 (USAF 1993g). Samples were collected from wells 47M01 (located at the upgradient edge of the parking lot), 47M03, and 47M05 to verify lead concentrations and to identify a possible upgradient source of lead. The sample from Well 47M05 was also analyzed for VOCs to verify the absence of BTEX.

Garrison Slough and French Creek. The sitewide surface water and sediment investigation at Eielson AFB was conducted in 1993 (see Section 2.6). Additional samples were collected as part of the 1994 SWMP field effort to address data gaps identified after the 1993 surface water and sediment investigation. The scope and rationale for the 1994 surface water and sediment samples are provided in Section 2.6.2.

2.6 SURFACE WATER AND SEDIMENT SAMPLING

Surface water and sediment quality data were needed to assess the risk to human health and the environment from releases of contaminants as a result of base activities. Human exposure to contaminants in surface water and sediment can occur through dermal contact or incidental ingestion during swimming or other water-related recreational activities. In addition, people could ingest fish caught from, or irrigate gardens with, potentially-contaminated surface water. Wildlife

can be exposed to contaminants through direct contact, and ingestion of water or contaminated prey.

The surface water and sediment investigation was conducted on a sitewide basis because surface water bodies cross OU boundaries and can receive contaminants from multiple OUs. The approach and methods are documented in *Work Plan, Surface Water and Sediment Investigation, Eielson AFB* (USAF 1993j). The primary objectives of the investigation were to 1) characterize the quality of surface water and sediment across Eielson AFB, 2) identify contaminated areas, and 3) identify the sources of contamination, if possible. These objectives were accomplished using the following approach:

1. Review and summarize surface water and sediment data from previous investigations.
2. Describe the probable current condition of surface water and sediment based on data from previous investigations.
3. Identify data gaps.
4. Conduct a sampling and analysis program to complete the characterization and provide data for use in the sitewide human health and biological risk assessments.

After reviewing the results of previous investigations, the specific objectives for the 1993 field investigation were identified as follows:

- Confirm levels of contamination in Garrison Slough, and identify the source(s) of contamination, if possible.
- Confirm the absence of contamination in French Creek and Piledriver Slough.
- Collect data for areas that were not adequately sampled during previous investigations, including Moose Creek, Lily Lake, and the Flightline Pond.
- Collect current contaminant concentration data for use in the sitewide human health and biological risk assessments.

Other data gaps were identified after the results of the 1993 biological risk assessment and surface water and sediment investigation were reviewed, and additional sampling was carried out in 1994. The approach and methods used for the 1994 surface water and sediment sampling were documented in the *1994 Sitewide Monitoring Program Sampling and Analysis Plan, Eielson AFB* (USAF 1994a). Sampling locations and parameters for the 1993 and 1994 field investigations are summarized in the following sections.

2.6.1 1993 Surface Water and Sediment Sampling

Table 2.2 identifies the sampling locations and analytical parameters for the 1993 surface water and sediment investigation. Sampling locations are shown in Figures 2.1 and 2.6.

Garrison Slough. Samples were collected from seven locations along Garrison Slough from its origin near source area LF03/FT09 to Transmitter Road at the north end of the base. Collection of a representative background sample from Garrison Slough was not possible because contamination

had been detected in samples collected as far upstream as source area ST49 in an area that only flows during spring runoff. The Garrison Slough sampling locations were as follows:

- GS00 near source area LF03/FT09, where continuous flow in the slough was first observed. Potential source areas of contamination that are upgradient of GS00 include LF03/FT09 (OU-5), ST49 (OU-1), and ST20 (OU-1). In addition, the orientation of the water table appears to slope from source areas ST13 and DP26 (OU-2) toward Garrison Slough during the spring thaw (USAF 1993a), indicating that these source areas could contribute to the slough on a seasonal basis.
- GS01 Quarry Street, approximately 400 m downstream of Station GS00. Assuming that the water table near source area SS37 also slopes towards Garrison Slough during the spring runoff, SS37 could be an additional source of contamination.
- GS02 near Outer Loop Road. It is approximately 400 m downstream of GS01, and 100 m upstream of the standing water near the inlet to the infiltration pond (GS03).
- GS03 inlet to the infiltration pond. Source area SS35 is adjacent to the slough at this location; the highest concentrations of pesticides in sediment were identified near this point in 1990 (HLA 1991).
- GS04 Central Avenue near source area ST11. This sampling point was intended to characterize the effect of the infiltration pond on water and sediment quality.
- GS05 Kodiak Street. This site is downstream of source areas ST18, ST48, WP60, and SS47.
- GS06 Transmitter Road. This site represents the quality of water and sediment leaving the base in Garrison Slough.

Contaminants of concern were identified by reviewing historical data for Garrison Slough. The historical data were obtained primarily from IRP investigations (HLA 1989, 1991). The IRP analyses were performed using EPA-approved methods, and the results were subjected to a data quality assessment to identify sampling or analytical problems that qualified the data. Another source of historical data was Bioenvironmental Engineering Services (BES) at Eielson AFB, which carries out various monitoring programs at the base. BES used similar sampling methods to those used during the sitewide investigation, and analyses were performed using EPA-approved methods. However, the data were not validated prior to use. Historical data are discussed further in Section 4.2.1. Contaminants of concern are identified in Table 2.2.

Surface water samples collected from Garrison Slough were analyzed for metals, arsenic, VOCs, gasoline range organics (GRO), DRO, pesticides, and PCBs (Table 2.2). Sediment samples were analyzed for metals, arsenic, DRO, pesticides, and PCBs. Water and sediment samples were not analyzed for SVOCs because they had not been previously detected (except for a trace of fluoranthene in one sediment sample collected in 1992). Sediment samples were not analyzed for VOCs because they also had not been previously detected.

French Creek. The historical data review indicated that the upland source areas LF04 and WP38 did not appear to be affecting water quality in French Creek; however, LF02 could be a source of VOC contamination (HLA 1989). Surface water and sediment samples were collected from the following locations in French Creek:

FCBG A background sample was collected approximately 8 km upstream (south) of the base, where French Creek crosses the Trans-Alaska pipeline (TAP) right-of-way (Figure 2.6).

FC01 Quarry Road, downgradient of the ski lodge (source area WP38)

FC02 downstream of source area LF04

FC03 downstream of source area LF02.

The French Creek samples were analyzed for the same parameters as samples from Garrison Slough (Table 2.2). The background water sample was not analyzed for VOCs because they were assumed to be absent.

Moose Creek and Piledriver Slough. One surface water and one sediment sample were collected from Moose Creek below the confluence of Garrison Slough (Station MC01) to establish surface water and sediment quality leaving the base. One surface water and one sediment sample were collected from Piledriver Slough immediately downstream of LF01 (Station PS01) to confirm that the landfill is not affecting the slough (Figure 2.6). These samples were analyzed for metals, arsenic, VOCs (water only), GRO (water only), DRO, pesticides, and PCBs (Table 2.2). The Moose Creek water and sediment samples were also analyzed for SVOCs because this site had not been previously characterized.

Lakes and Ponds. Surface water and sediment samples were collected from the Flightline Pond at the north end of the flightline, and from Lily Lake (Stations FP01 and LL01, respectively). The data from Lily Lake were used to assess whether it has been affected by contaminants from Engineer Hill (Figure 2.6). These samples were analyzed for SVOCs in addition to the other parameters because no previous data from these sites existed. Samples were not collected from Spruce (formerly Hardfill) Lake at ST10 because the OU-2 RI provided a relatively complete characterization of its quality (USAF 1993d).

The 1993 sampling locations and analytical parameters are summarized in Table 2.2. Sample results and associated QC data were reviewed in accordance with EPA guidelines for evaluating organic and inorganic analyses (EPA 1988a, 1988b). Sample results were qualified if needed.

2.6.2 1994 Surface Water and Sediment Sampling

After the 1993 data from the biological risk assessment and surface water and sediment samples were reviewed, data gaps were identified that required additional sampling in 1994. The results of the biological risk assessment indicated that PCBs in lower Garrison Slough could pose a risk to ecological receptors. PCBs were not detected in the 1993 surface water or sediment samples, although PCBs were detected in sediment samples collected in 1990 (HLA 1991). In addition, pesticide concentrations in the 1993 samples were lower than those measured in 1990. Therefore, water and sediment samples were collected from nine Garrison Slough stations in August 1994 to verify the pesticide concentrations measured in 1993 and to locate a source of PCBs in Garrison Slough by resampling the location with the highest PCB concentration measured in 1990 (Arctic Avenue bridge), and locations upstream and downstream of this location. Six of the stations were identical to those sampled in 1993 (Table 2.2). Three additional stations were added near the Arctic Avenue bridge to confirm the PCBs measured in 1990 (Figure 2.1):

GS07 upstream of the Arctic Avenue bridge

GS08 immediately downstream of the Arctic Avenue bridge

GS09 adjacent to source area SS30.

After PCBs were found in the samples collected from the three new stations, four additional sediment samples were collected in September 1994 to further delineate the magnitude and extent of the hotspot (Figure 2.1). Stations GS10, GS11, and GS12 were located between Station GS07 at the Arctic Avenue bridge and the next upstream station (GS05 at Kodiak Street). Station GS13 was located downstream of Arctic Avenue between stations GS08 and GS09.

The Garrison Slough water samples were analyzed for VOCs in addition to pesticides and PCBs to monitor the impact of adjacent source areas on the slough. Sediment and water samples were also collected from two stations in French Creek (FC01 and FC03) to verify the pesticide and PCB concentrations measured in 1993. The 1994 sampling locations and analytical parameters are summarized in Table 2.2.

2.7 1994 AQUATIC BIOTA SAMPLING

As part of the 1993 sitewide biological risk assessment for Eielson AFB, aquatic biota (vegetation, invertebrates, and fish) samples across the base were collected and analyzed for contaminants of concern identified in the OU RIs (pesticides, PCBs, polynuclear aromatic hydrocarbons [PAHs], and lead). Results are reported in the biological risk assessment report (USAF 1995e). The 1993 fish tissue samples analyzed for the biological risk assessment were a composite of fillet (muscle tissue), liver, and gall bladder. The contaminant concentrations measured in these samples were used in a screening baseline risk assessment to identify potential sitewide risks to human health and to direct the 1994 sitewide sampling effort to fill any remaining data gaps (USAF 1994c). Results of the screening baseline risk assessment suggested that the consumption of fish from Garrison Slough could pose a risk to human health, primarily because of PCB and PAH tissue residues. Pesticides (DDT, DDD, and DDE) were also detected in fish tissue, but contributed less to the total risk. However, the relevance of the risk estimates was questionable because the tissue samples did not necessarily represent the portion of a fish that a person would typically consume, and the variability in tissue concentrations at any one site was not known (i.e., only one fish was collected at each sampling location). In addition, no off-base samples were collected in 1993, and it was not clear whether the contaminants in fish tissue were restricted to (and originated from) Eielson AFB, or were accumulated from an offsite source.

Therefore, in 1994 an aquatic biota sampling effort was carried out to accomplish the following:

- Assess the relative contribution of Eielson AFB to contaminants found in fish near the base.
- Determine the spatial distribution of contaminants in fish (i.e., within-site and among-site variability).
- Determine contaminant concentrations at reference and offsite locations (i.e., establish background concentrations).

Aquatic invertebrates and macrophytes were also sampled at the stream locations to determine whether fish tissue concentrations can be correlated with other ecosystem components. Invertebrates and macrophytes were not collected at Piledriver Slough or lake locations because these stations were used for offsite monitoring (i.e., establishment of background concentrations in fish). The methods and rationale used to conduct the biota sampling effort are described below.

2.7.1 Sampling Locations

Fourteen locations were selected for sampling of aquatic organisms in 1994 (Table 2.5, Figures 2.1, 2.6, and 2.7). These comprise locations both on and off base and include both stream and lake environments. Three locations were sampled on French Creek, three locations on Garrison Slough, two on Moose Creek, two on Piledriver Slough, and one each on Hidden Lake, Grayling Lake, and 28 Mile Pit. The final location was on the Chatanika River, well outside the influence of the settled areas along the Fairbanks/Eielson AFB corridor (Figure 2.7).

Fish species identified for sampling were grayling, northern pike, and longnose sucker, as available. Arctic grayling (*Thymallus arcticus*) was the target species to allow greater comparison of contaminant concentrations among sites and years.

2.7.2 Sampling and Sample Preparation

Fish. Fish were collected by hook-and-line or by backpack electroshocker at all collection sites. Samples were wrapped in aluminum foil, individually bagged, and placed in an ice-cooled container following collection in the field.

Skin-on fillets were prepared using a stainless steel knife. Liver and gall bladder tissues were frozen and archived for future analysis, if needed. All samples were rinsed in deionized water, placed in certified precleaned glass containers, and frozen for shipment to the analytical laboratory.

Macroinvertebrates. Aquatic invertebrates were collected at all stream locations except for Piledriver Slough, which was an offsite monitoring location. Three different methods were used: kick-sampling with a modified Surber sampler, dip netting, and hand-picking available substrata (e.g., rocks, woody debris, submerged vegetation). The objective was to collect a minimum of 50 g per station of invertebrates for analysis. Samples were placed in certified clean jars in the field, stored on ice, and later frozen for shipment to the analytical laboratory.

Aquatic macrophytes. Approximately 50 g of submerged vegetation was collected at each stream sites (except for Piledriver Slough). Samples were placed in certified clean jars in the field, stored on ice, and later frozen for shipment to the analytical laboratory.

Sample Splits And Duplicates. Duplicate and split samples were made to determine intra- and interlaboratory error, respectively. Duplicates were made for 15% of the total number of fish samples sent to the analytical laboratory. Splits were made for 5% of the fish samples collected. No splits or duplicates were obtained for aquatic invertebrates or macrophytes because of the small amount of sample material available for analysis.

2.7.3 Analytical Methods

Aquatic biota samples were analyzed for PCB Aroclors, pesticides, and PAHs. Analytical methods are summarized below.

PCB Aroclors/Chlorinated Pesticides. Tissue samples were homogenized using a Tekmar tissuemizer. Approximately 5 g of homogenized tissue was extracted with methylene chloride using a roller under ambient conditions, following a procedure that is based on methods used by the National Oceanic and Atmospheric Administration (NOAA) for its Status and Trends Program (Krahn et al. 1988). Samples were then cleaned using silica/alumina (5% deactivated) chromatography followed by high-performance liquid chromatography (HPLC) cleanup. Extracts were analyzed using gas chromatography/electron capture detection (GC/ECD). Extracts were exchanged to methyl-t-butylether and analyzed by capillary column GC/ECD using a standard operating procedure (SOP) based on EPA Method 8080 (EPA 1986). The primary column used was a J&W DB-1701 capillary column (30 m by 0.25 mm inner diameter). Samples were analyzed for four Aroclor mixtures (1242, 1248, 1254, and 1260) and a total of 16 chlorinated pesticides. All results were confirmed on a separate parallel confirmatory column (DB-17). Target detection limits of 1.5 µg/kg wet weight were met for all pesticide compounds. PCB Aroclor detection limits of 20 µg/kg wet weight were also met.

PAHs. Samples were extracted with methylene chloride using a roller under ambient conditions, following a procedure that is based on methods used by the NOAA for its Status and Trends Program (Krahn et al. 1988). Samples were then cleaned using a silica/alumina (5% deactivated) chromatography followed by HPLC cleanup (Krahn et al. 1988). Extracts were quantified using gas chromatography/mass spectrometry (GC/MS) in the selected ion mode (SIM), following a procedure based on EPA Method 8270 (EPA 1986). Target detection limits of 20 nanograms per gram (ng/g) wet weight were met for all PAH compounds.

2.7.4 Data Analysis

Replicate data from each site were evaluated to determine within- and among-site variability. Some variability in contaminant tissue concentrations is expected because of seasonal migrations, size and age of fish, and other life history factors (e.g., feeding habits). However, it is assumed that the fish spend most of their time near the sample location or are present long enough that measured tissue concentrations represent equilibrium or steady-state conditions.

Contaminant concentrations in the 1994 biota samples were compared with the values measured in 1993, and conclusions of the biological risk assessment (USAF 1995e) were re-evaluated in terms of the new data. The fish tissue contaminant concentrations were also used in the sitewide baseline risk assessment (USAF 1995d).

2.8 SITEWIDE TECHNICAL REPORTS

Most of the data collected during the sitewide investigation from 1992 to 1994 was released in a series of technical reports to make the information available for review and use in other studies. The technical reports are compiled and synthesized in this comprehensive sitewide RI report. The sitewide technical reports completed from 1992 to 1994 are as follows:

Hydrology

Automatic Water-Level Measurements, Eielson Air Force Base, September 1991-August 1992
(USAF 1993a)

Summary and Evaluation of Hydraulic Property Data Available for Eielson Air Force Base, Alaska
(Spane and Thorne 1994)

Sitewide Water Table Elevations at Eielson Air Force Base, September 1991-September 1993
(USAF 1993h)

Soil and Groundwater Quality

Sampling and Analysis Results for the North Boundary Wells, Eielson Air Force Base, Alaska
(USAF 1992c)

Background Soil Quality, Eielson Air Force Base, Alaska (USAF 1993c)

Background Groundwater Quality, Eielson Air Force Base, Alaska (USAF 1993b)

Sitewide Groundwater Monitoring Program 1993 Report, Eielson Air Force Base, Alaska
(USAF 1993g)

Sitewide Monitoring Program 1994 Report, Eielson Air Force Base, Alaska (USAF 1995b)

Surface Water and Sediment

Surface Water and Sediment Investigation Draft Report, Eielson Air Force Base, Alaska
(USAF 1994e).

Complete analytical results, QC data, and results of data quality reviews are included in these reports (with the exception of the hydrology reports).



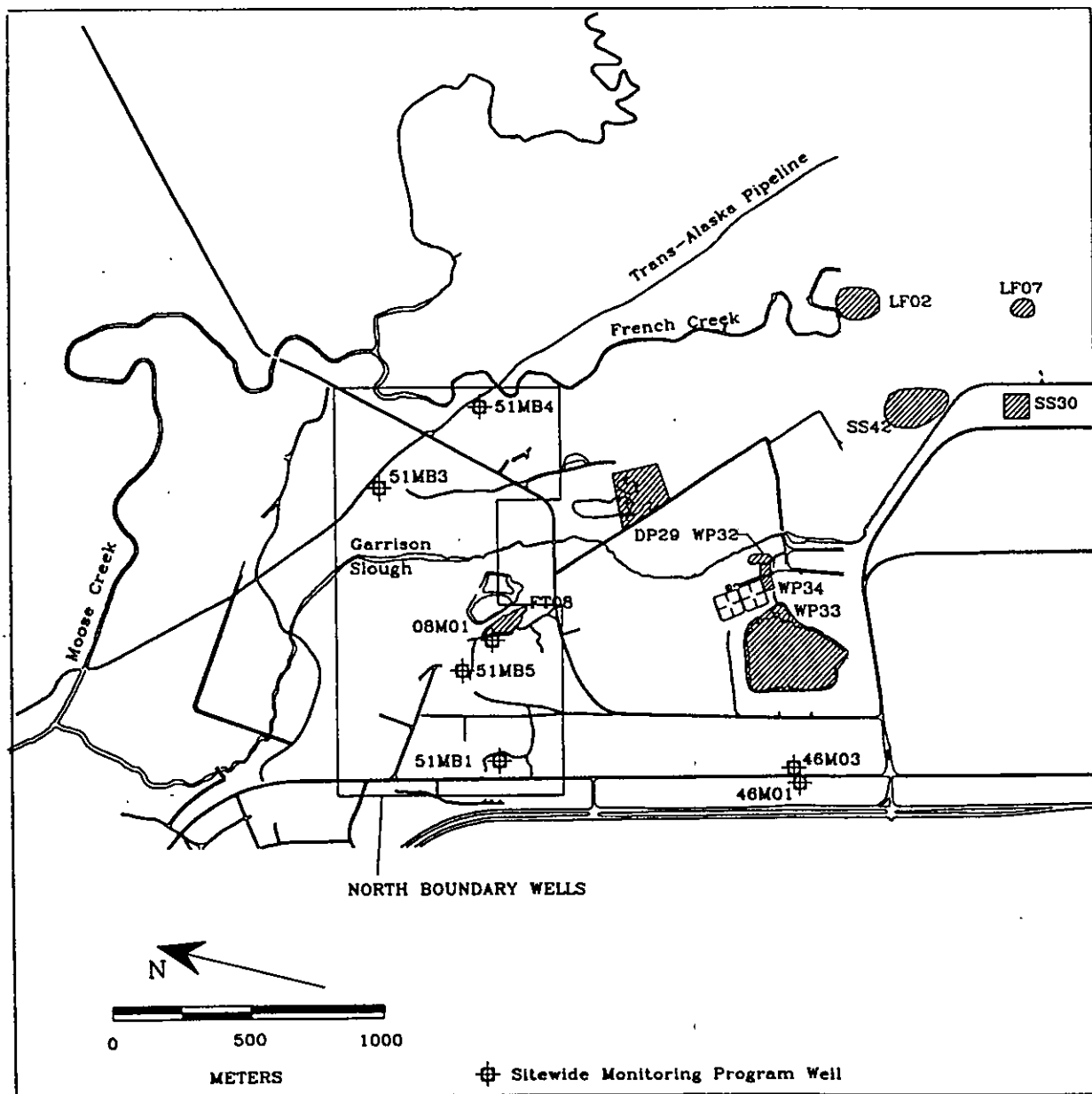


FIGURE 2.2. Sitewide Monitoring Well Locations in the Lowland Area (North)

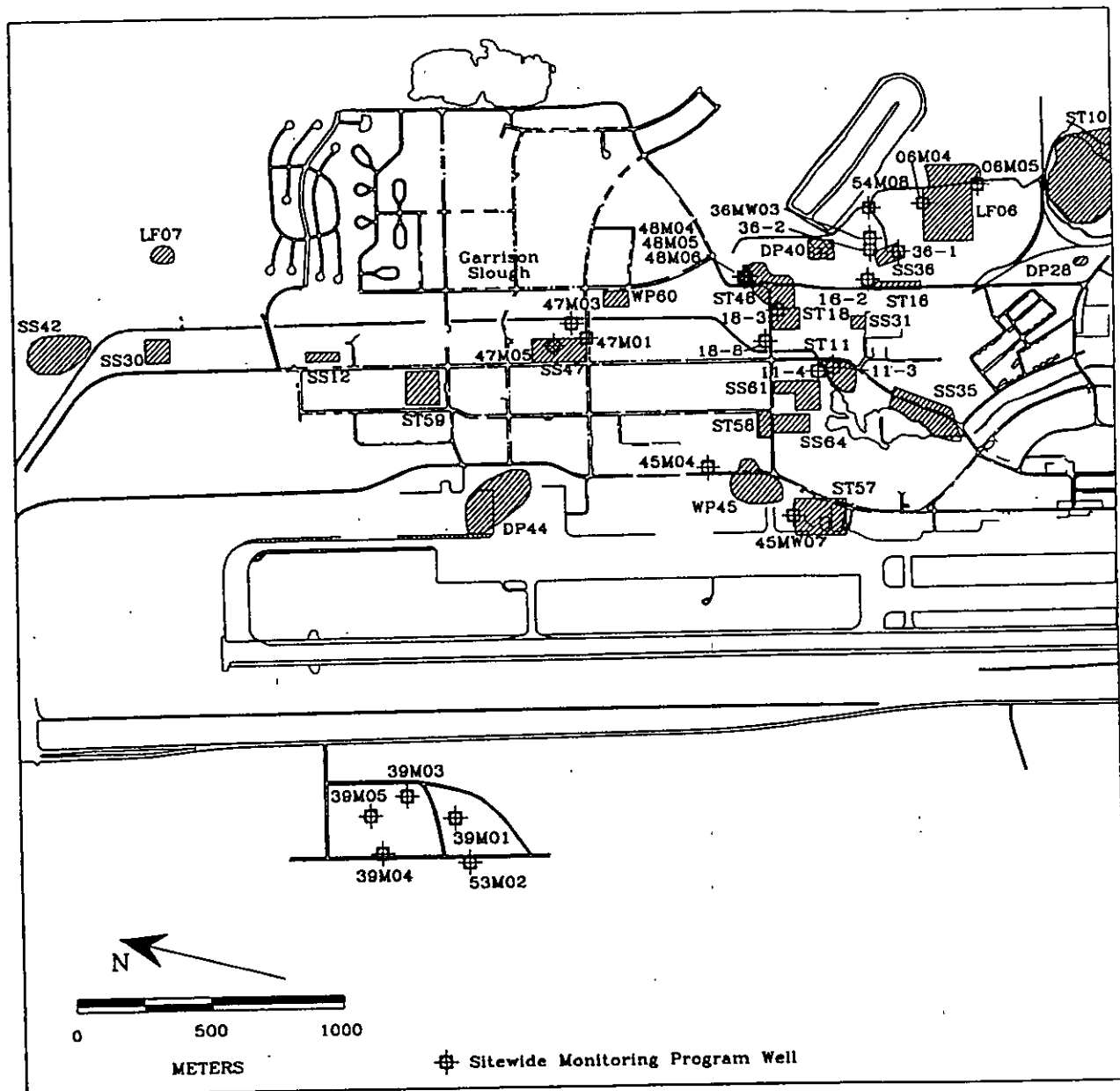


FIGURE 2.3. Sitewide Monitoring Well Locations in the Lowland Area (Middle)

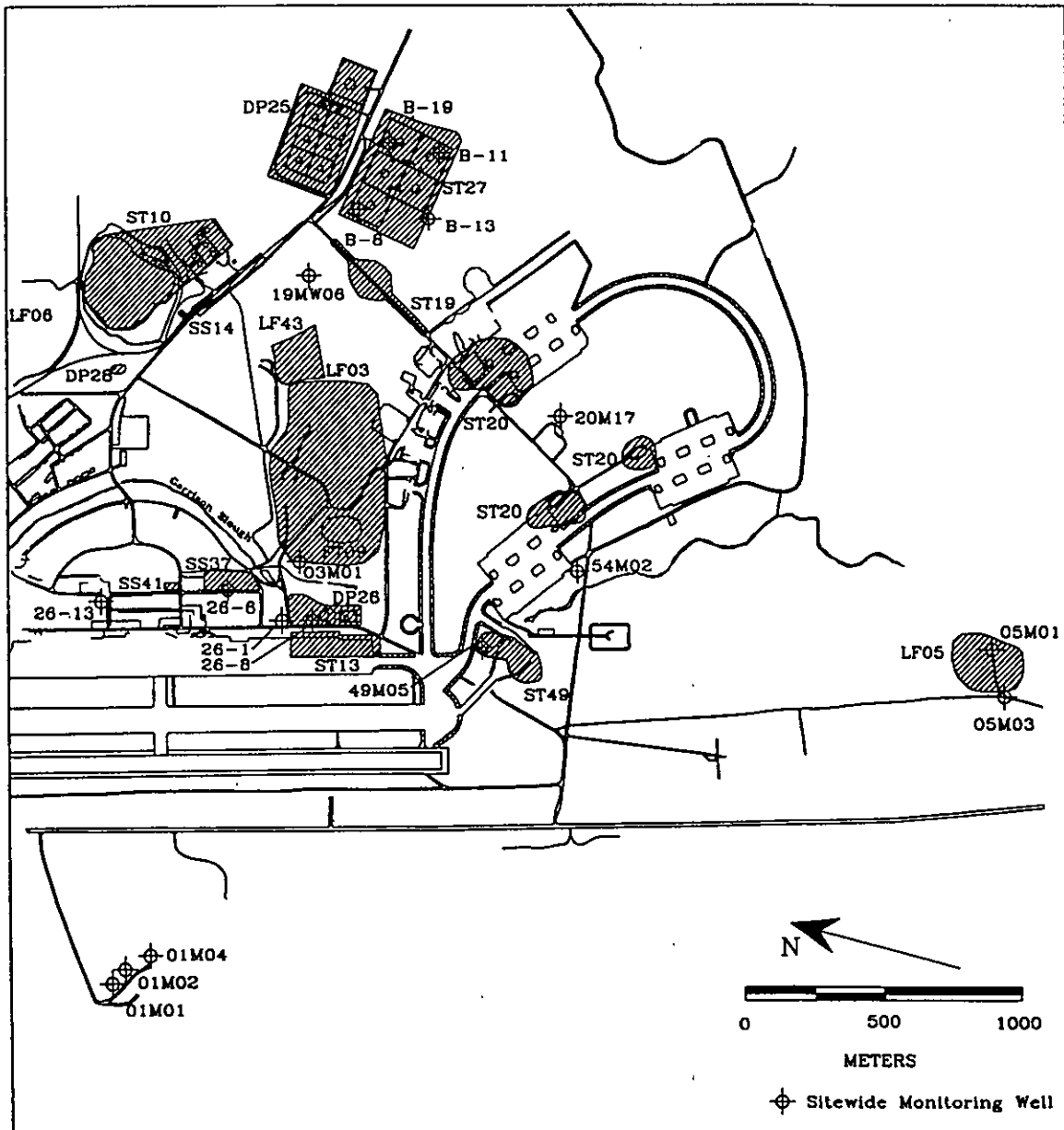


FIGURE 2.4. Sitewide Monitoring Well Locations in the Lowland Area (South)

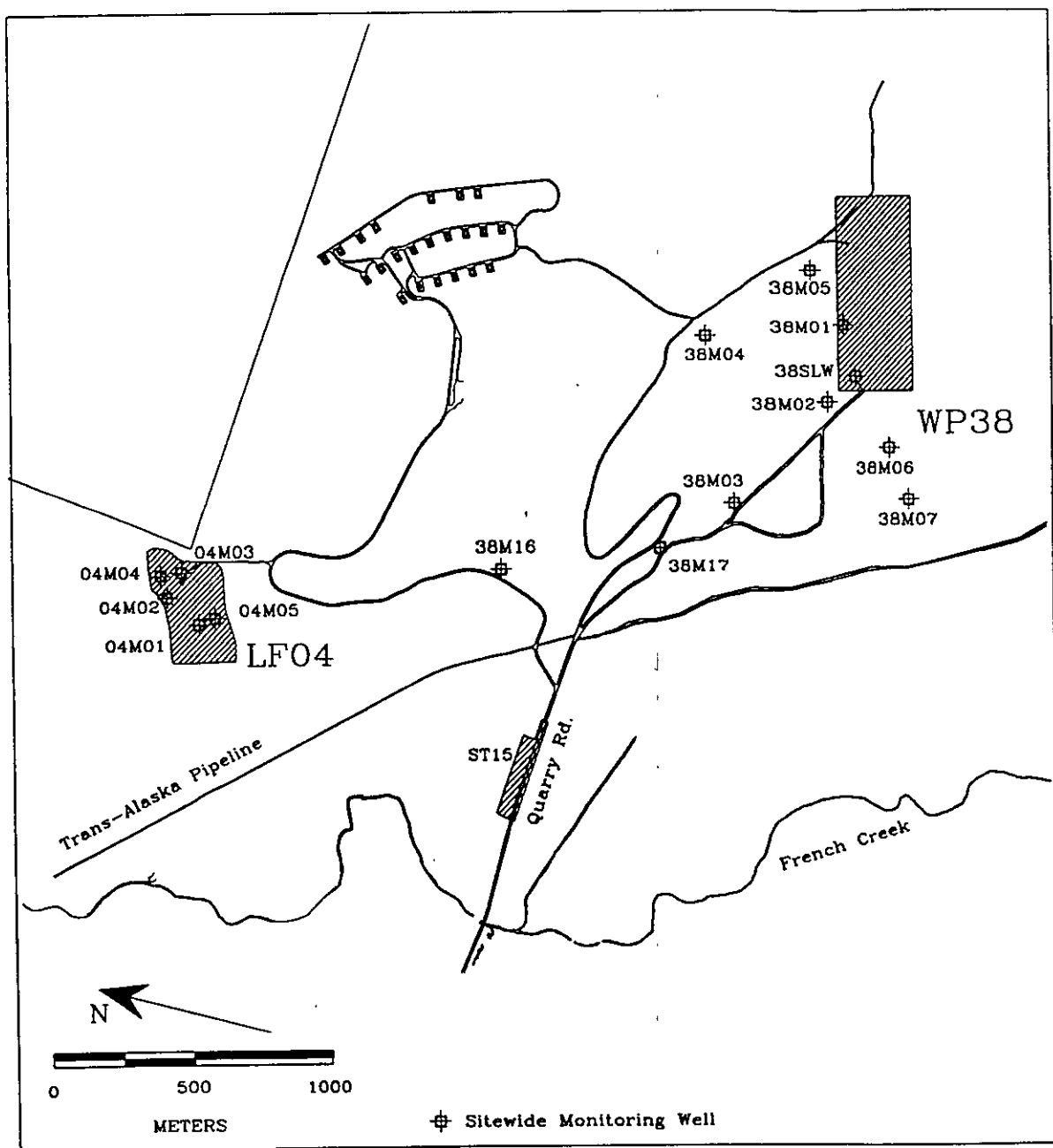


FIGURE 2.5: Sitewide Monitoring Well Locations in the Upland Area

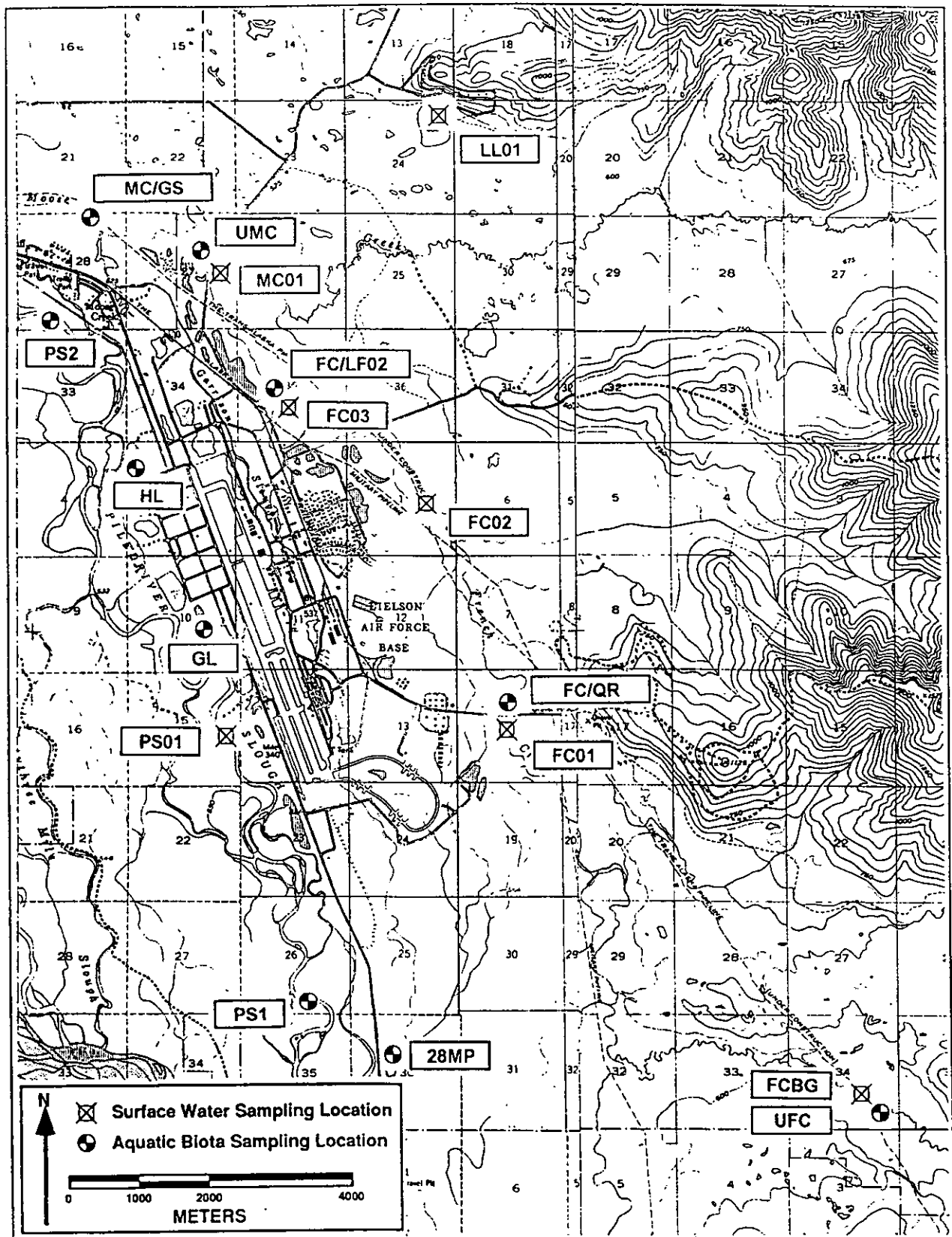


FIGURE 2.6. Sample Locations in Outlying Areas

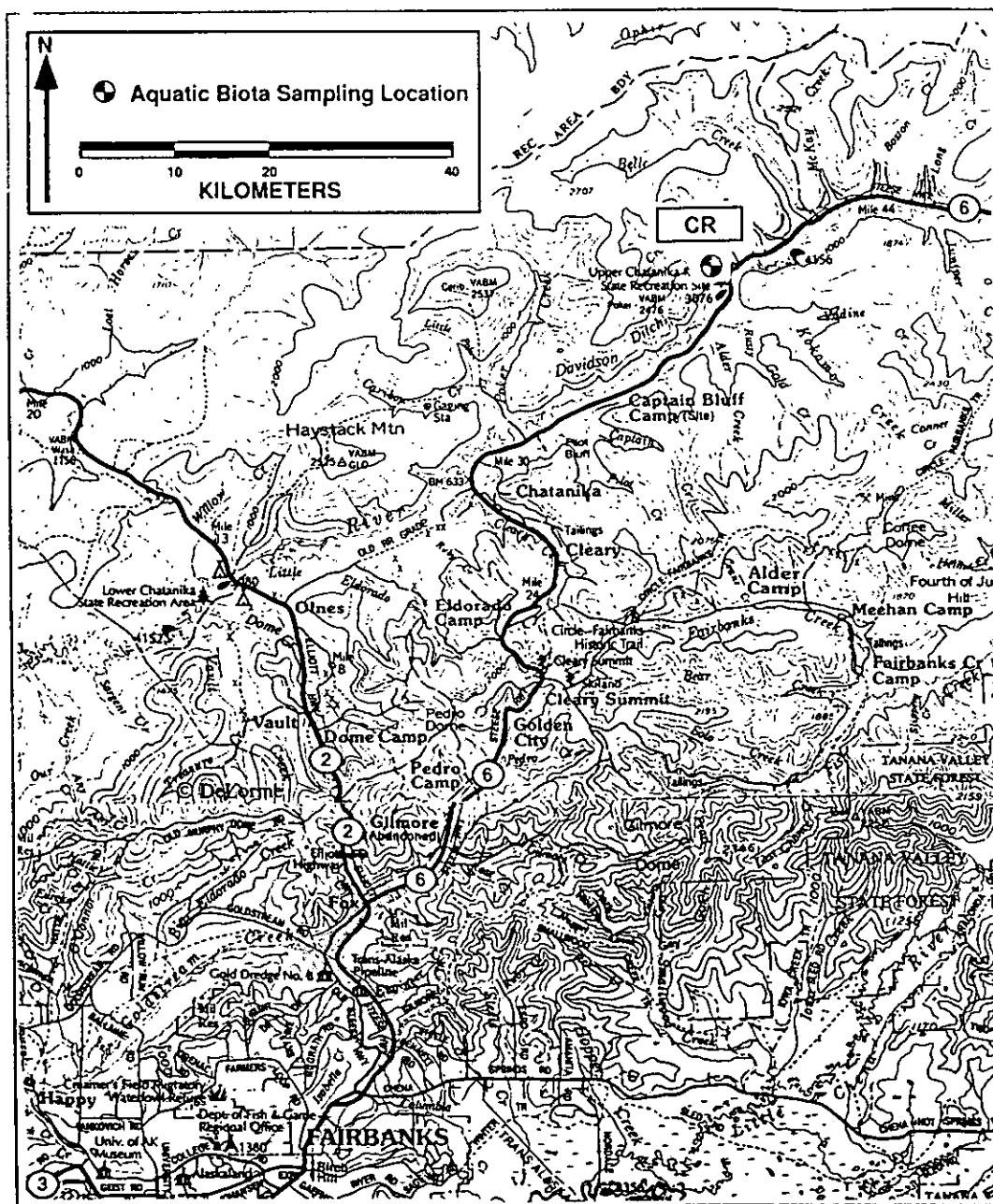


FIGURE 2.7. Chatanika River Sampling Location

TABLE 2.1. Summary of Media and Contaminants of Concern for Site-wide Investigation

Medium	Contaminants of Concern	Explanation
Groundwater	BTEX naphthalenes solvents (TCE, DCE, vinyl chloride) metals	Contaminants identified in groundwater during source area investigations.
Soil	petroleum hydrocarbons pesticides PCBs metals	Extent of soil contamination adequately characterized during source area investigations; only background soil samples were analyzed under the site-wide investigation.
Surface Water	BTEX solvents (TCE, DCE, vinyl chloride) pesticides metals	Contaminants identified in surface water samples from previous investigations and potential contaminants released from adjacent source areas.
Sediment	petroleum hydrocarbons pesticides PCBs metals	Contaminants identified in sediment samples from previous investigations and potential contaminants released from adjacent source areas.
Air	None identified.	No airborne contaminants identified in previous investigations.

TABLE 2.2. Sitewide Sampling and Analysis Programs

Investigation and Year	Source Area and/or Objective	Sampling Locations	Contaminants of Concern	Analytical Parameters	Method	Technical Report
Background Soil Quality 1991	Characterize background concentrations of constituents in soil	Borrow pits (21 samples) Powerline corridor (60 samples) Upland area (10 samples)	Samples from uncontaminated areas	metals TPH pesticides PCBs	CLP 418.1 CLP/8080 CLP/8080	<i>Background Soil Quality, Eielson AFB (March 1993)</i>
Sitewide Groundwater Monitoring 1992	Characterize background concentrations and major groundwater chemistry	01M01 01M02 05M03 17-2 20-1B 20M17 20M18 20M21 38M03 48M04 48M05 48M06	Samples from uncontaminated areas	metals arsenic lead major anions TOC alkalinity TDS TPH	6010 7060 7421 300.0 9060 ASTM 1067A&B 209B 418.1	<i>Background Groundwater Quality, Eielson AFB (March 1993)</i>
	Monitor shallow groundwater quality at downgradient edge of base	North Boundary Wells - 08M01, 51MB1, 51MB3, 51MB4, 51MB5	fuel-related compounds, solvents, metals	VOCs TPH metals arsenic lead	8010/8020 418.1 6010 7060 7421	<i>Sampling and Analysis Results for the North Boundary Wells (November 1992)</i>
Sitewide Groundwater Monitoring Program 1993	Evaluate seasonal differences in background concentrations	01M01 01M02 05M03 17-2 20-1B 20M17 20M18 20M21	Samples from uncontaminated areas	metals arsenic lead VOCs	6010 7060 7421 8010/8020	<i>Sitewide Groundwater Monitoring Program 1993 Report (December 1993)</i>
	Monitor shallow groundwater quality at downgradient edge of base	North Boundary Wells - 08M01, 51MB1, 51MB3, 51MB4, 51MB5	fuel-related compounds, solvents, metals	VOCs DRO metals arsenic lead	8010/8020 AK102 6010 7060 7421	

TABLE 2.2. Sitewide Sampling and Analysis Programs

Investigation and Year	Source Area and/or Objective	Sampling Locations	Contaminants of Concern	Analytical Parameters	Method	Technical Report
Sitewide Groundwater Monitoring Program 1993	OU-2 - ST11 and ST18: confirm 1991 data	11-3 18-3	BTEX	VOCs	8010/8020	Sitewide Groundwater Monitoring Program 1993 Report (December 1993)
	OU-2 - ST11 and ST18: compare results to background concentrations	11-4 18-8	arsenic	metals arsenic	6010 7060	
	OU-2 - ST19: obtain data for fate and transport modelling	19-2A	BTEX	VOCs	8010/8020	
	OU-2 - ST19: monitor contamination downgradient of ST19	19MW06				
	OU-2 - DP26: monitor BTEX plume	26-1 26-6 26-8	BTEX lead (26-1 and 26-8 only)	VOCs lead	8010/8020 7421	
	OU-5 - LF03: confirm 1992 metals data	03M01	metals arsenic	metals arsenic	6010 7060	
	SER - LF05, LF06, and SS47: support recommendations for no further action	05M01 06M04 06M05	metals VOCs SVOCs pesticides PCBs	metals arsenic VOCs SVOCs pesticides PCBs	6010 7060 8010/8020 8270 8080 8080	
		47M05	fuel-related compounds, lead	VOCs SVOCs lead	8010/8020 8270 7421	

TABLE 2.2. Sitewide Sampling and Analysis Programs

Investigation and Year	Source Area and/or Objective	Sampling Locations	Contaminants of Concern	Analytical Parameters	Method	Technical Report
Sitewide Monitoring Program 1994	Monitor background concentrations	01M01 01M02 05M03 20M17 46M01 46M03 54M02 54M08	Samples from uncontaminated areas	metals	6010/6020	Sitewide Monitoring Program 1994 Draft Report (January 1995)
	Monitor shallow groundwater quality at downgradient edge of base	North Boundary wells - 08M01, 51MB1, 51MB3, 51MB4, 51MB5	fuel-related compounds, solvents, metals	VOCs DRO metals	8010/8020 AK102 6010/6020	
	OU-1 - ST48: monitor benzene adjacent to Base Supply Well D	48M04 48M05 48M06	Benzene	VOCs	8010/8020	
	OU-1 - ST49: monitor BTEX in area of greatest contamination	49M05	BTEX	VOCs	8010/8020	
	OU-2 - ST10: monitor BTEX downgradient of Spruce Lake	10MW12 (new well)				
	OU-2 - ST11 and ST18: verify absence of contamination	11-3 18-3				
	OU-2 - ST19: obtain data for fate and transport modelling	19MW07 (new well)	BTEX	VOCs	8010/8020	
	OU-2 - ST19: monitor contamination downgradient of ST19	19MW06				

TABLE 2.2. Sitewide Sampling and Analysis Programs

Investigation and Year	Source Area and/or Objective	Sampling Locations	Contaminants of Concern	Analytical Parameters	Method	Technical Report
Sitewide Monitoring Program 1994	OU-2 - DP26: monitor BTEX plume	26-6 26MW17 (new well) 26MW18 (new well) 26MW19 (new well)	BTEX	VOCs	8010/8020	Sitewide Monitoring Program 1994 Draft Report (January 1995)
	OU-3 - WP45: confirm data collected for natural attenuation study	45M04 45MW07	TCE DCE BTEX	VOCs	8010/8020	
	OU-4 - ST27: verify absence of fuel contamination, monitor lead	B-8 B-11 B-13 B-19	fuel-related compounds, lead	metals DRO GRO	6010/6020 AK102 AK101	
	OU-4 - SS36: confirm absence of VOCs and elevated metals	36-1 36-2 36MW03	BTEX TCE metals	VOCs metals	8010/8020 6010/6020	
	OU-4 - SS39/SS63: verify absence of fuel-related contaminants	39M01 39M03 39M04	POL products PAHs lead	DRO GRO metals	AK102 AK101 6010/6020	
	OU-5 - LF04: verify absence of organic contaminants, monitor metals	04M01 04M02 04M03	POL products solvents phenols metals	VOCs DRO GRO phenols metals	8010/8020 AK102 AK101 8270 6010/6020	
	OU-6 - WP38: monitor contaminant concentrations at base of Ski Hill	38M01 38M02 38M03 38M04 38M05	BTEX metals	VOCs metals	8010/8020 6010/6020	
	SER - LF01, LF05: monitor landfill	01M04 05M01	metals	metals	6010/6020	

TABLE 2.2. Sitewide Sampling and Analysis Programs						
Investigation and Year	Source Area and/or Objective	Sampling Locations	Contaminants of Concern	Analytical Parameters	Method	Technical Report
Sitewide Monitoring Program 1994	SER - ST16: verify absence of fuel contamination	16-2	BTEX	VOCs	8010/8020	Sitewide Monitoring Program 1994 Draft Report (January 1995)
	SER - SS47: establish existence of upgradient source, monitor lead	47M01 47M03 47M05	BTEX lead	VOCs lead	8010/8020 6020	
	SER - DP55: monitor drinking water well	Birch Lakes Water Supply Well	BTEX metals	VOCs metals	8010/8020 6010/6020	
	Garrison Slough: monitor VOC contamination, verify 1993 pesticide and PCB data, locate source of PCBs	GS00 GS01 GS03 GS04 GS05	BTEX TCE DCE pesticides PCBs	VOCs (water only) pesticides PCBs	8010/8020 8080 8080	
	Garrison Slough: delineate extent of PCB contamination in sediment	GS10 GS11	PCBs	PCBs (sediment only)	8080	
Surface Water and Sediment Investigation 1993	Verify 1993 pesticide data	FC01 FC03	pesticides PCBs	pesticides PCBs	8080 8080	Surface Water and Sediment Investigation Draft Report, Eielson AFB (May 1994)
	Characterize nature and extent of surface water and sediment contamination	Garrison Slough French Creek Moose Creek Piledriver Slough Flightline Pond Lily Lake	fuel-related compounds, solvents, pesticides, PCBs, metals	VOCs GRO (water) DRO pesticides PCBs metals arsenic lead SVOCs ⁽¹⁾	8010/8020 AK101 AK102 8080 8080 8080 6010 7060 7421 8270	
		7 stations 4 stations 1 station 1 station 1 station 1 station				

TABLE 2.2. Sited Sampling and Analysis Programs

Investigation and Year	Source Area and/or Objective	Sampling Locations	Contaminants of Concern	Analytical Parameters	Method	Technical Report
Biological Sampling 1994	Characterize extent and variability of contaminant residues in fish, aquatic invertebrates, and macrophytes	Chatanika River Upper French Creek Upper Moose Creek Moose/Garrison Confluence Upper Garrison Slough Mid Garrison Slough Lower Garrison Slough French Creek/Quarry Road French Creek/LFO2 Piledriver Slough 28 Mile Pit Grayling Lake Hidden Lake	pesticides PCBs PAHs	pesticides PCBs PAH	see Section 2.5.3	Not previously reported

Analytical Laboratories:

Background Soil Quality
 1992 Background Groundwater Quality (all parameters except TPH)
 1992 Background Groundwater Quality (TPH)
 1993 Sited Groundwater Monitoring Program (all parameters except GRO and DRO)
 1993 Sited Groundwater Monitoring Program (GRO and DRO)
 1994 Sited Monitoring Program (all parameters except GRO and DRO)
 1994 Sited Monitoring Program (GRO and DRO)
 1994 Sited Monitoring Program (samples from wells 10MW12, 19MW07, and 26MW19)
 Surface Water and Sediment Investigation (all parameters except GRO and DRO)
 Surface Water and Sediment Investigation (GRO and DRO)
 1994 Biological Sampling

CH2M Hill, Redding, California
 DataChem Laboratories, Salt Lake City, Utah
 Laucks Laboratories, Seattle, Washington
 DataChem Laboratories, Salt Lake City, Utah
 Enasco CRL, Garden Grove, California
 Lockheed Analytical Services, Las Vegas, Nevada
 Analytical Resources, Inc., Seattle, Washington
 Northern Testing Laboratories, Inc., Fairbanks, Alaska
 DataChem Laboratories, Salt Lake City, Utah
 Enasco CRL, Garden Grove, California
 Battelle/Marine Sciences Laboratory, Sequim, Washington

(1) Moose Creek, Flightline Pond, and Lily Lake only.

TABLE 2.3. List of Wells for Automatic Water-Level Monitoring

Well	Screened Depth (m)	Service Dates	
		From	To
01M03	not known	9/24/93	present
02M01	2.2-5.2	9/24/93	present
03M05	2.7-8.8	4/24/92	7/7/92
03M05	2.7-8.8	8/12/92	9/1/93
03M06	9.4-12.5	4/24/92	7/7/92
03M06	9.4-12.5	8/12/92	9/1/93
03M07	27.3-30.2	4/24/92	7/7/92
03M07	27.3-30.2	8/12/92	9/1/93
10-5	1.0-11.7	9/12/91	2/17/93
10-8	1.4-9.0	9/13/91	4/24/92
10-8	1.4-9.0	4/24/92	9/23/93
10MW08I	10.3-16.4	11/20/91	9/23/93
10MW09	1.0-7.0	10/17/91	5/4/92
10MW09	1.0-7.0	6/17/92	8/13/92
10MW11	0.8-6.7	10/17/91	2/17/93
11-1	1.3-9.0	9/13/91	11/14/92
11-5	0.6-6.7	9/12/91	9/24/93
11-5	0.6-6.7	8/17/94	present
11-6	1.1-7.2	9/12/91	4/23/92
13MW05	1.4-7.3	11/20/91	5/19/93
18-1	1.1-8.7	9/13/91	8/14/92
18-4	0.9-7.0	9/13/91	8/14/92
18-5	1.2-7.3	9/13/91	11/14/92
18-5	1.2-7.3	5/19/93	present
18MW05I	11.1-17.1	11/20/91	11/14/92
18MW05I	11.1-17.1	5/19/93	present
19-1	1.0-8.6	9/13/91	2/17/93
19-3	0.8-11.4	9/13/91	2/17/93
19-4	1.2-12.0	9/13/91	present
20M20	1.9-4.9	9/25/93	11/28/94
20M20	1.9-4.9	8/18/94	present

TABLE 2.3. List of Wells for Automatic Water-Level Monitoring			
Well	Screened Depth (m)	Service Dates	
		From	To
26-2	1.5-9.2	11/20/91	4/23/92
26-2	1.5-9.2	7/7/92	present
26MW02I	9.8-15.8	12/17/91	present
26-6	1.1-11.7	9/13/91	7/7/92
26-6	1.1-11.7	8/12/92	9/24/93
45M01	2.1-5.2	10/6/92	9/24/93
45M01	2.1-5.2	9/27/93	present
45M03I	11.6-14.6	8/15/92	9/27/93
45M03I	11.6-14.6	9/27/93	present
48M04	3.0-6.1	9/12/91	present

TABLE 2.4. North Boundary Well Measurements, August 1992			
Well	Diameter (in)	Well Depth (ft below top of casing)	Depth to Water (ft below top of casing)
08M01	2	15.00	6.91
51MB1	2	18.48	6.83
51MB3	2	18.23	5.72
51MB4	2	19.60	11.73
51MB5	2	16.11	6.75

TABLE 2.5. 1994 Aquatic Biota Samples

Category	Surface Water Body	Description	Station ID	Number of Samples		
				Fish	Invertebrates	Macrophytes
Reference/ Background	Chatanika River	Steese Highway	CR	4 grayling	1	1
	Upper French Creek	8 km upstream of Quarry Rd. bridge	UFC	4 grayling	1	1
	Upper Moose Creek	Transmitter Rd.	UMC	4 grayling	1	1
	Moose Creek	Downstream of Moose Creek/Garrison Slough Confluence	MC/GS	4 grayling	1	1
Eielson AFB Streams	Upper Garrison Slough	SS35/WTP pond	UGS/SS35	4 pike	1	1
	Middle Garrison Slough	SS47/Burger King	MGs/SS47	4 grayling	1	1
	Lower Garrison Slough	SS30/Lower Garrison	LGS/SS30	4 grayling	1	1
	French Creek	Quarry Rd.	FC/QR	4 grayling	1	1
	French Creek	LF02	FC/LF02	4 grayling	1	1
	Piledriver Slough #1	South end of base	PS1	2 grayling	NC ^(a)	NC
Offsite Monitoring	Piledriver Slough #2	North end of base	PS2	2 grayling	NC	NC
	28-Mile Pit	28-Mile Pit	28MP	1 pike	NC	NC
	Grayling Lake	Grayling Lake	GL	2 grayling	NC	NC
	Hidden Lake	Hidden Lake	HL	2 rainbow trout	NC	NC

(a) NC None collected at offsite monitoring locations (see Section 2.7).

3.0 SITE CHARACTERISTICS

Descriptions of the physical, chemical, and land-use characteristics of Eielson AFB are described in this section. Results of the sitewide hydrogeologic, background soil, and background groundwater quality studies described in Section 2.0 are incorporated into these descriptions.

3.1 LOCATION AND PHYSIOGRAPHY

Eielson AFB is in the Tanana River Valley in the eastern-central portion of interior Alaska, about 3 km east of the Tanana River (Figure 1.1). The base is about 40 km southeast of Fairbanks and about 160 km south of the Arctic Circle. Eielson AFB encompasses approximately 80 sq km.

The Tanana River Valley is a large sediment-filled basin between the Alaska Range on the south and the Yukon-Tanana Uplands on the north (Pewe and Reger 1983). It is underlain by Quaternary fluvial and glaciofluvial sediments shed from the rapidly uplifted Alaska Range, approximately 160 km south (Pewe 1982). The Tanana River is a braided stream heading in the Alaska Range near the Canadian border and joining the Yukon River near the community of Tanana. A small eastern portion of Eielson AFB lies in the Yukon-Tanana Uplands, primarily underlain by Paleozoic and Precambrian schist and phyllite and Mesozoic granitic intrusions (Pewe et al. 1966; Weber et al. 1978). The flood plain of the Tanana River is interrupted by erosional remnants of crystalline bedrock.

Topography is flat and essentially featureless within the developed portion of Eielson AFB, with elevations ranging from 160 m to 168 m above mean sea level (m msl), and sloping downward to the north-northwest. Elevations in the hilly, eastern portion of the base are as high as 343 m msl. Except for some fuel storage areas, a ski area, and the Trans-Alaska Pipeline, the eastern portion of the base is largely undeveloped.

3.2 CLIMATE AND METEOROLOGY

Eielson AFB is in the continental climatic zone that covers interior Alaska. The climate in this zone is characterized by large diurnal and annual temperature variations, low precipitation, and low humidity. The climate is semiarid because moist maritime air masses are blocked in the south by the Alaska Range and in the north by the Brooks Range (Pewe 1982). Large annual variations in temperature and solar radiation occur because of the high latitude.

Historical climatic data for the period 1944 through 1984 are presented in Table 3.1. Average summer temperatures range between 6.7°C and 16°C. Average temperatures during the winter season range between -26°C and -12°C. Extreme temperatures recorded between 1944 and 1984 at Eielson AFB were 34°C for July and -53°C for January.

Annual precipitation in this area averages 36 cm, which includes 183 cm of snow. Average monthly precipitation ranges from 1.3 cm to 6.4 cm, with rainfall generally highest in July and August. The evaporation rate is approximately 36 cm/yr, which equals the mean annual precipitation.

3.3 GEOLOGY

No detailed geologic map of Eielson AFB exists, and the subsurface geology of the area is not completely known. Precambrian and Paleozoic-age pelitic schists, micaceous quartzites, and subordinate phyllite and marble outcrop within the hills northeast of the base. These units have been locally metamorphosed by a series of Cretaceous to lower Tertiary granodioritic to quartz monzonitic intrusions. The intrusions are also related to precious metal deposits near Eielson AFB and elsewhere in the Fairbanks region. The headwaters of both French Creek and Moose Creek are underlain by Tertiary granodiorite of the Eielson pluton (Weber et al. 1978).

During the Quaternary period, rapid uplift of the Alaska Range combined with alternating glacial advances and retreats built up enormous alluvial fans along the southern margin of the Tanana River Valley. Aggradation of the river plain built up a thick and heterogeneous sequence of unconsolidated silts, sands, and gravels. Unconsolidated sediments are approximately 60 m to 90 m thick beneath Eielson AFB. Glacial outwash plains at the base of the Alaska Range provided wind-blown silts that have been transported northward and deposited as loess mantles along the crystalline uplands. Silt has also accumulated at lower elevations with plant debris in organic muck deposits.

Numerous small faults are mapped in the pre-Tertiary metamorphic units. Larger regional faults border the major petrologic units within the bedrock and probably extend under the Tanana floodplain deposits (Beikman 1980). In 1937, a magnitude 7.3 earthquake occurred with an epicenter at Salcha Bluff, about 21 km southeast of Eielson AFB (Pewe 1982).

3.4 HYDROGEOLOGY

The developed portion of Eielson AFB is located on the floodplain of the Tanana River, which is underlain by unconsolidated fluvial and glaciofluvial deposits. The thickness of these unconsolidated floodplain sediments ranges up to approximately 200 m (Pewe 1975). The sediments are composed primarily of sand and gravel with cobbles up to 20 cm in diameter. The silt and clay content is variable, but generally less than 10%. The floodplain sediments overlie a crystalline bedrock formation called the Birch Creek Schist (Figure 3.1).

Surface water bodies near Eielson AFB include rivers, creeks, sloughs, lakes, ponds, and wetlands. Surface drainage at Eielson AFB is generally north-northwest, parallel to the Tanana River (Figure 3.2). Several small sloughs or creeks pass through the base and discharge to the Tanana River. Moose Creek is the main receiving stream for small local drainages around the base. Both French Creek, along the eastern edge of the base, and Piledriver Slough, along the western edge, discharge to Moose Creek just above its confluence with the Tanana River. Garrison Slough also discharges to Moose Creek.

Garrison Slough passes directly through the developed portion of the base and consists primarily of engineered drainage channels. Portions of Garrison Slough are enclosed in culverts near the refueling loop area (source area ST20). Before 1979, effluent from the base sewage treatment plant was discharged to Garrison Slough (CH2M Hill 1982). Stream characteristics estimated in August 1987 for French Creek, Moose Creek, Piledriver Slough, and Garrison Slough are presented in Table 3.2.

Eielson AFB contains 13 lakes totaling 1.3 sq km, 54 ponds totaling 1 sq km, and 10 designated wetlands totaling about 1 sq km. One of the lakes and six of the ponds are natural; the remaining lakes and ponds are old borrow pits or gravel pits (HLA 1990).

3.4.1 Hydrostratigraphy

The uppermost aquifer under the developed portion of Eielson AFB is contained in the unconsolidated fluvial and glaciofluvial sediments. This aquifer is about 50 m to 100 m thick. It is generally shallow (i.e., less than 5 m below ground surface [bgs]), and forms ponds and sloughs in areas of low topography, where ground surface intersects the water table. The aquifer within the sediments parallels the Tanana River. It is bounded on the northeast by the Yukon-Tanana uplands and is estimated to be 70 km to 80 km wide at Eielson AFB (CH2M Hill 1982). The aquifer occurs under unconfined (water table) conditions, although discontinuous permafrost layers can act as confining or semiconfining layers, especially in undeveloped areas of the base.

In upland areas, such as Engineer Hill and the ski hill, the uppermost aquifer is within the fractured schist bedrock. Groundwater in this formation exists both in fractures and in micropores within the bedrock matrix. Groundwater flow is predominantly controlled by the location and orientation of the fractures. The uppermost aquifer in the bedrock could be either confined or unconfined.

3.4.2 Aquifer Recharge and Discharge

The alluvial aquifer at Eielson AFB is recharged primarily by the infiltration of snowmelt and rainfall, and by subsurface flow and runoff from the Yukon-Tanana upland area. In some places and during certain seasons, the aquifer is also recharged by the Tanana River and its tributaries (Anderson 1970). Recharge from these streams occurs primarily when the streams are at high stage. This could result from snowmelt at higher elevations, which is usually later in the year than recharge from local snowmelt. The Tanana River derives most of its flow from the Alaska Range and a lesser amount from the Yukon-Tanana upland. Its discharge generally peaks in July, when the melting of glaciers and snowfields in the Alaska Range is at a maximum (Nelson 1978). Recharge from local snowmelt usually peaks in April or May, depending on weather conditions.

The effect of the Tanana River stage on aquifer water levels was not seen in water-level monitoring data collected on the base, except possibly at wells in the western portion of the base during July 1994 (see Section 3.4.4). Local recharge from snowmelt generally has a greater influence on the aquifer at the base. The seasonal input of recharge from snowmelt and the inputs from periods of heavy rain were clearly reflected in aquifer water-level data, as discussed in Section 3.4.4. Recharge from snowmelt has been enhanced in some source areas by disposing of large amounts of snow collected from roads and parking lots.

Groundwater leaves Eielson AFB as underflow and as discharge to surface streams on the base. The discharge to surface streams is greatest when the water table has been elevated by infiltrating snowmelt. Garrison Slough runs northward through the center of the base and clearly receives groundwater discharge. It has no other source in the area upstream from the water treatment plant during dry weather. However, at the water treatment plant, excess groundwater from the base water supply wells is discharged to a pond that forms part of Garrison Slough. This elevates the water level in the Water Treatment Plant (WTP) pond and in the slough for some distance downstream (Figure 3.3). The interaction between Garrison Slough and the groundwater flow system is discussed further in the next subsection.

3.4.3 Relationship of Groundwater and Surface Water

Garrison Slough. Staff gages located in Garrison Slough provided information about the slough's interaction with the groundwater flow system. Measurements from the gages were compared with water-level data from nearby monitoring wells. Staff gage locations are shown on the water table map in Figure 3.3. Appendix B provides detailed information on water-level measurements and additional water table maps. Staff gage measurements were not possible during winter and early spring because the slough was covered by ice and snow. However, the available measurements indicate that the highest water-level elevations in Garrison Slough coincided with the highest water table elevations, which were a result of the annual spring recharge event. As shown in Appendix A, the highest water table elevation during 1992 occurred in late May and was about 0.5 m higher than the winter and late summer groundwater levels. Staff gage measurements of Garrison Slough at Quarry Street, upstream of the WTP pond, and at Central Avenue and Arctic Avenue, downstream of the WTP pond, showed that the slough was 0.1 m to 0.3 m higher during May 1992 than during the late summer. The greater increase in spring groundwater levels relative to the slough shows that the water table gradient dips more steeply toward the slough during times of highest water table, indicating that greater discharge to the slough during the spring recharge event.

At source area ST11, water-level measurements in monitoring wells and staff gage measurements at Central Avenue showed that the water level in Garrison Slough was slightly higher (0.03 m to 0.12 m) than the elevation of the adjacent groundwater except during the spring recharge event. These measurements suggest that in the area immediately downstream from the WTP pond, Garrison Slough recharges the aquifer except during the major recharge event. To verify this finding and further investigate the interaction between the aquifer and Garrison Slough, a direct comparison was made between the water level in wells 37-1, 35M06, 35M08, 60M02, and 60M04 and the water level in the slough immediately adjacent to each of these wells. Measurement locations are shown in Figure 3.4. The measurements were made on May 24, 1994, using a surveyor's level and stadia rod. As shown in the well hydrographs in Appendix A, the peak water table elevation corresponding to spring melt occurred at the beginning of May in 1994. Groundwater levels were still elevated when the measurements were made, but had dropped to within about 0.2 m of the pre-spring levels.

Results of the groundwater and slough water level comparison are shown in Table 3.3. From these measurements, it can be seen that the groundwater flow direction was toward Garrison Slough at all of the wells except Well 35M08, which is adjacent to source area SS35 and the WTP pond. At Well 35M08, the pond was 0.02 m higher than the adjacent groundwater level. The slough apparently recharges the aquifer, except during the spring recharge event, near the WTP pond and for some distance downstream. However, at Well 60M02, about 1 km downstream from the pond, the flow direction was again toward the slough. The very small water-level difference (0.02 m) between the WTP pond and adjacent groundwater at the time of the measurements indicates that the amount of aquifer recharge from the pond was probably small. Water table maps in Figure 3.3 and Appendix B show that the pond does not have a major effect on sitewide groundwater flow direction or gradient.

Based on the measurements presented in Table 3.3, the water level in Garrison Slough is believed to be lower than the water table throughout the year over most of the slough's length. Because it has no other natural source, the slough is a drain for the shallow aquifer. However, discharge of excess water to the WTP pond causes the water table to be slightly lower than the slough at the pond and for a short distance (<1 km) downstream, except during the spring recharge event.

French Creek and Piledriver Slough. HLA (1990) reported that both French Creek and Moose Creek were influent streams (losing water to the aquifer) in the eastern (upstream) portion of the base and effluent streams (receiving recharge from the aquifer) in the northwestern (downstream) portion of the base. However, comparison of water levels measured at a staff gage installed in French Creek near source area LF02 and water levels in adjacent LF02 wells during the fall of 1992 indicates that the water level in the French Creek was 0.2 m to 0.5 m higher than the groundwater. The staff gage location is shown in Figure 3.3. Therefore, French Creek was apparently recharging the aquifer at this time and location.

Measurements were also taken during the fall of 1992 from a staff gage installed in Piledriver Slough adjacent to source area LF01 (Figure 3.3). The water level in the stream was about 0.1 m higher than the water level in adjacent Well O1M02 from July through September. The water levels were approximately equal during October. Piledriver Slough was, therefore, apparently recharging the aquifer during the late summer at this location. The October measurements indicate equilibrium conditions between the slough and the groundwater system. The slough was frozen in November. Water levels in Piledriver Slough can be elevated during mid- and late summer, which is generally the period of highest flow for the Tanana River.

3.4.4 Automatic Water-Level Measurements in Wells

As discussed in Section 2.3, automatic water-level monitoring equipment was installed at selected wells in September 1991 to support the remedial investigation of OU-2. Table 2.3 provides information on the locations of the automatic water-level monitoring equipment, and well locations are shown in Figure 2.1. Details concerning the water-level monitoring equipment and results are provided in Appendix A.

Objectives of automatic water-level monitoring were as follows:

- Determine seasonal variations in groundwater levels.
- Monitor the effect of recharge events (rainfall and snowmelt).
- Determine the influence of pumping base water supply wells.
- Assess the influence of Garrison Slough.
- Provide information about horizontal and vertical hydraulic gradients.

Hydrographs showing water table elevations measured at four representative monitoring wells over a 3-year period are presented in Figure 3.5. Hydrographs showing all of the automatically measured water-level elevations are provided in Appendix A. These hydrographs show the timing and magnitude of seasonal changes in water table elevation. In general, the aquifer fluctuated uniformly across the developed portion of the base, indicating that the monitored interval is continuous. Variations were observed at some wells because of local influences including surface water bodies, pumping wells, and enhanced recharge from snow disposal. In addition to the automatic water-level monitoring, manual water-level measurements were collected monthly from selected monitoring wells and 10 staff gages at Eielson AFB (see Section 3.4.5). These measurements were compared with the automatic water-level data and are shown on the hydrographs in Appendix A.

Temporal Changes in Water Levels. At most wells on the developed portion of the base, the water table declined from the beginning of the measurement period in September 1991 to a minimum elevation in the second week in November (see Well 10-8 in Figure 3.5). During this period, the discharge from the aquifer to the Tanana River and its tributaries apparently exceeds the recharge from precipitation. After the second week in November, the water table rose gradually until mid-April. The gradual rise through the winter months is attributed to the freezing of the channels of the Tanana River and its tributaries. This prevented groundwater from effectively draining into the surface streams. The pattern of decreasing water levels through the fall and gradually increasing levels in the winter was observed each year.

In April 1992, the water table began rising dramatically, and a maximum was observed in the last week of May. The maximum water level was about 0.3 m to 0.6 m higher than the minimum water level measured in November. This major recharge event coincided with the spring thaw, when runoff from snow-melt was at a maximum. After the spring recharge event, the water table elevation decreased from the end of May until reaching its minimum in the fall. The spring recharge event was also clearly seen during 1993 and 1994. However, it occurred about three weeks earlier during the latter 2 years.

The effect of the Tanana River stage on the aquifer at Eielson AFB was not apparent in the hydrographs, indicating that local recharge during the spring thaw and from precipitation has a greater influence on the aquifer at the base. Well 01M03 is located near Piledriver Slough and is closer to the Tanana River than any of the other monitored wells. Water levels recorded in Well 01M03 showed a small peak during July 1994 that could coincide with high stage of the Tanana River (Figure 3.6). However, the same peak is even more pronounced at other wells on the base, including Well 19-4 (Figure 3.6), and was probably caused by a precipitation event. Comparison of the response at Well 01M03 with that at Well 19-4 indicates that the major peaks are attenuated. However, the general water-level trends are similar.

Several small water-level peaks were observed during the summer months in all of the monitored wells. These peaks appear to coincide with major rainstorms at Eielson AFB. Figure 3.7 shows a comparison of daily precipitation and the water levels recorded at Well 10-8 during the summer of 1992. After the spring recharge event and summer rainstorms, the water table dropped to its minimum elevation in the fall.

Influence of Pumping Wells. Nearly all of the monitored wells were influenced by pumping at base water supply wells. The greatest short-term water-level fluctuations were observed in Well 48M04 (Figure 3.5). Water levels in this well show fluctuations of up to 0.5 m in less than 12 hours during August and September 1992. These short-term stresses on the aquifer appear to originate in the vicinity of the power plant and are seen at nearly all the monitored wells. Because of the nature of the fluctuations (i.e., rapid changes of relatively high amplitude), they are believed to be artificially induced by base water supply and power plant cooling wells. Three wells in the vicinity of the power plant could be responsible for the fluctuations. The main water supply well for the base, Well D, is located on the north side of the power plant, and two large-diameter cooling wells (wells 21 and 22) are located on the southeast side of the power plant (Figure 2.1). Well D, which is screened from 29 m bgs to 35 m bgs, is pumped continuously at about 3800 L/min. Wells A and B are used when Well D is undergoing repair or maintenance and during periods of high water demand. Wells 21 and 22 are used to supply cooling water to the power plant during the summer months, from about early June to late September. These wells are screened from 21.6 m bgs to 33.8 m bgs and from 23.2 m bgs to 35.4 m bgs, respectively. When in use, both wells are pumped at a combined rate of about 11,000 L/min.

Distortion of water table elevation contours in the vicinity of the power plant (Figure 3.3) illustrates the effect of pumping at the water supply wells on groundwater flow direction and gradient. Because of the high permeability of the aquifer, drawdown from the pumping wells is observed over a large area, but has relatively small magnitude. The hydrographs in Appendix A show that drawdown from pumping of water supply wells 21 and 22 is about 0.3 m at Well 18-5, located about 300 m from the pumping wells. The drawdown is less than 0.2 m at Well 11-5, located about 450 m from the pumping wells. Drawdown from pumping of water supply Well D is not apparent on the hydrographs because it is constant. However, the drawdown from this well is expected to be about one-third of the drawdown from pumping wells 21 and 22. Because of the small magnitude of the drawdowns and the relatively large spacing of monitoring wells, closed elevation contours that would indicate a cone of depression do not appear around the pumping wells on water table maps in Appendix B. However, a cone of depression probably does exist within a few hundred meters of the pumping wells.

Barometric Pressure Effects. Barometric pressure fluctuations were measured using a barometric transducer at Well 26-6 and were recorded on the data logger installed at this well. The measurements were compared with water-level changes in selected wells to determine the effect of barometric pressure change on water levels in the monitoring wells. Generally, water levels in wells monitoring an unconfined aquifer are not expected to display appreciable changes as a result of atmospheric pressure change because the pressure change is "felt" simultaneously both at the well and within the aquifer. Water levels in wells in confined aquifers, however, typically respond inversely to atmospheric pressure changes (i.e., as atmospheric pressure increases, the water table elevation decreases). It was suspected that the shallow top of the aquifer might freeze in some areas on the base, resulting in a change from unconfined to confined aquifer conditions. Figure 3.8 shows comparisons of changes in barometric pressure and water levels measured in Well 26-6 during the fall and winter. No significant change is apparent as a result of the atmospheric pressure changes during either season. These data indicate that the top of the aquifer did not freeze and create confined conditions. In some cases, infiltration from rainfall events associated with low atmospheric pressure could influence the water level in wells and give a false indication of confined conditions. However, at Eielson AFB, no infiltration is expected during the winter months.

3.4.5 Groundwater Flow Direction and Gradient

Water levels have been manually measured at selected monitoring wells since September 1991. Measurements were made monthly during the period August 1992 through August 1993, and less frequently during the remaining time periods. The water-level data and contour maps of the water table elevations for each month are presented in Appendix B. Procedures and equipment are also discussed in Appendix B.

Water table elevation contours based on measurements taken in September 1992 are shown in Figure 3.3. As indicated on the figure, the direction of groundwater flow was generally to the north-northwest over most of the developed portion of the base. The gradient is generally between 0.001 and 0.002.

Groundwater flow directions are influenced by seasonal recharge from snowmelt, by discharge to Garrison Slough, and by pumping of base water supply wells. Flow direction and gradients can also be locally influenced by relatively large amounts of infiltration at snow disposal areas. Increased hydraulic heads can occur at these areas in the spring and early summer. The direction of groundwater flow is nearly constant throughout the year except in the vicinity of these local influences.

Water-level data from paired wells (adjacent shallow and intermediate or shallow, intermediate, and deep) at source areas LF03, ST10, ST18, and ST26 were compared to provide information about vertical hydraulic gradients across the site (well locations are shown in Figure 2.1). The shallow wells are generally screened across the upper 6 m or less of the aquifer. The intermediate wells are open to a 3-m long interval starting about 5 m to 8 m below the top of the aquifer. A deep well at source area LF03 (Well 03M07) has a 3-m long screen starting at about 25 m below the top of the aquifer.

Figure 3.9 shows the automatic water-level measurements recorded at paired wells from December 1991 through September 1993. Comparison of water levels measured in paired wells indicated vertical head differences between 0 m and 0.15 m. Uncertainty in the automatic measurements is about 0.03 m (see Appendix A), and the uncertainty in the difference is about 0.06 m. Therefore, there appears to be a small, but measurable, variation in vertical heads within the unconfined alluvial aquifer. The paired wells show nearly identical responses to recharge events and other stresses. This is particularly evident in wells 18-5 and 18MW51, which were affected by pumping at nearby water supply wells.

The greatest head difference was seen at source area LF03. Water levels in the intermediate depth Well 03M06 were up to 0.15 m lower than the water levels in both shallow Well 03M05 and deep Well 03M07 until the spring recharge event in mid-April 1993. The water level in Well 03M06 then converged with the other two wells. The transducer measuring Well 03M06 failed in May 1993. However, manual water-level measurements showed that the water level in Well 03M06 again dropped below the other two wells during the summer. Therefore, it appears that a downward gradient could exist in the upper aquifer and an upward gradient could exist in the deeper part of the aquifer at this site. A possible physical explanation is a higher permeability zone at the intermediate depth that "drains" more easily, resulting in a lower head. The vertical variation in heads also indicates that vertical hydraulic conductivity could be lower than horizontal hydraulic conductivity.

Water level in the intermediate depth Well 26-21 was consistently 0.03 m to 0.05 m lower than the water level in the shallow Well 26-2, suggesting a downward gradient in the upper part of the aquifer at this site as well. The manual water-level measurements for these wells were in close agreement with the transducer data. There was a gap in the data from Well 26-2 during the spring of 1992. However, the water levels did not converge during the 1993 spring recharge event as they did at LF03.

As shown in Figure 3.9, water levels measured at wells 10-8 and 10MW81 also indicated a downward gradient in the upper part of the aquifer. The water levels converged during the 1992 spring recharge event. The high peak in the automatic water-level measurements at 10MW81 during the 1993 spring recharge event has not been explained. No manual water-level measurements were taken at 10MW81 during this period. Therefore, it is not certain whether this was a data acquisition problem or a real change in water level.

As shown by the hydrographs for wells 18-5 and 18MW51 in Figure 3.9, the apparent vertical gradient at source area ST18 was reversed from that observed at the other paired wells, indicating a potential for upward flow. However, the magnitude of water-level differences was generally smaller than at the other sites and was approximately equal to the measurement uncertainty. Effects of pumping at nearby water supply wells are clearly seen in the hydrographs. The difference in measured heads appears to diminish during the low water-level periods of the summer when pumping effects are seen.

3.4.6 Aquifer Hydraulic Properties

During 1989, two multiple-well pumping tests and 30 single-well slug tests were conducted in the shallow alluvial aquifer underlying the developed portion of the base (HLA 1989). These tests have been evaluated and reanalyzed, and results are presented in Appendix C. A pumping test was also conducted on the fractured bedrock aquifer at source area ST56 during 1994. Details and complete results of this test are presented in Appendix D. The test at source area ST56 resulted in a relatively low hydraulic conductivity estimate of 0.1 meters per day (m/d) for the fractured bedrock aquifer.

The earlier pumping tests in the alluvial aquifer were reanalyzed because the original analyses incorrectly assumed an elastic aquifer response, whereas the data clearly display nonelastic (i.e., delayed yield) unconfined aquifer response. The hydraulic conductivities determined from the reanalyses were not significantly different from the original results. However, the reanalysis approach also permitted calculation of specific yield for the aquifer.

One of the pumping tests was conducted at a site about 100 m northeast of source area SS36. Well 54M05 was used as the pumped well and wells 54M06, 54M07, and 54M08 as observation wells. Reanalysis of the test data indicated a hydraulic conductivity of approximately 150 m/d and specific yield of 0.23 for the aquifer in this area. The other test was conducted at a site between ST20 and ST49 by pumping at Well 54M01 and monitoring observation wells 54M02, 54M03, and 54M04. The resulting hydraulic conductivity calculated from reanalysis of this test was 450 m/d and the best estimate for specific yield was 0.07.

An evaluation of the slug tests is also presented in Appendix C. The evaluation concluded that the majority of the slug tests reported in HLA (1989) do not provide reliable estimates of hydraulic properties. The main reason is that slug test responses cannot be analyzed for intervals having transmissivity higher than about 700 sq m/d (Spane and Thorne 1994; Cooper et al. 1967). The two multiple-well pumping tests described above indicate transmissivities of 1000 to 2900 sq m/d for the typical 6.37-m screened interval length. For a transmissivity of 1000 sq m/d, the slug response would be 85% dissipated within the first second of the test.

One slug test was conducted on well 38M03 in the bedrock aquifer at source area WP38. This test was able to be analyzed because of the lower transmissivity of the bedrock aquifer. The hydraulic conductivity result of 0.4 m/d calculated by HLA (1989) is considered to be reliable. Two slug tests performed on deeper wells in the alluvial aquifer showed an oscillatory response and had not been previously analyzed. Analyses of these two oscillating tests were conducted and are presented in Appendix B. They resulted in hydraulic conductivity ranging from 74 m/d to 126 m/d. Results of the other slug tests were not considered valid because of limitations in the slug test method for characterizing high permeability aquifers and, in some cases, because of shortcomings in the data collection and analysis procedures (Appendix C).

3.4.7 Influence of Permafrost

Discontinuous permafrost exists throughout the Tanana River floodplain sediments (Nelson 1978). Well logs for wells drilled at Eielson AFB during the 1940s and 1950s indicate layers of permafrost in sand and gravel between about 5 m bgs and 37 m bgs (Feulner and Williams 1962). Permafrost was not reported in well logs for monitoring wells drilled in the developed part of the base after 1986 (these wells have a maximum depth of 18 m bgs to 30 m bgs). Removal of the original ground cover and development on the base have caused most of the permafrost in the lowland area

to thaw. Permafrost occurs in the silty eolian deposits blanketing the upland area of the base, and in deposits between 0.6 m bgs and 4.5 m bgs at source areas SS14, ST15, and ST19. These areas are located in the southeast portion of the base, which is less developed. Permafrost in alluvial floodplain deposits generally has a low ice content, and ice is restricted to pore spaces or thin seams in silt and clay (Pewe 1982).

The effects of permafrost on groundwater flow in the shallow aquifer at Eielson are minor because it exists in only a few limited areas. Where permafrost has been encountered, it was generally in silty sediments that are expected to have relatively low permeability. Permafrost probably makes these sediments even less permeable and may inhibit vertical groundwater flow in some areas. The existence of permafrost could also decrease the effective thickness of the aquifer, resulting in higher hydraulic gradients in some areas.

3.5 SOILS

Prior to the background soil sampling effort, the U.S. Department of Agriculture, Soil Conservation Service's soil survey of Eielson AFB was reviewed and summarized. This summary is provided in Appendix E. The soil types can be classified into three broad groups: sand and gravel, fine-grained fluvial (alluvial), and loess. The first two groups are the coarse- and fine-grained fractions, respectively, of the fluvial and glaciofluvial sediments that underlie the Tanana River Valley. The loess soils are windblown silts that blanket the upland area of the base.

When runways and structures were built at Eielson AFB, the original silts and clays in the uppermost soil horizon were stabilized with sand and gravel from borrow pits. Thus, in the developed portion of the base, a typical soil profile consists of sand and gravel underlain by original fine-grained fluvial soils. Fine-grained fluvial soils are still at the surface in areas where the ground surface has not been modified.

Field descriptions and complete analytical results for background soil samples collected in 1991 are provided in Appendix E. Sample locations are shown in Figure 2.1. A summary of the 1991 background data for selected metals and TPH in each type of soil at Eielson AFB is provided in Table 3.4. Pesticides were detected in only two samples of sand and gravel fill and in one sample of fine-grained fluvial sediment; therefore, mean background values were not calculated. The pesticides, 4,4'-DDT and 4,4'-DDD, were detected in one sample of fill from Twin Lake at concentrations of 14.0 micrograms per kilogram ($\mu\text{g}/\text{kg}$) and 9.3 $\mu\text{g}/\text{kg}$, respectively. Traces of 4,4'-DDE in two samples and 4,4'-DDD in one sample from Twin Lake were detected below the quantitation limit, and a trace of 4,4'-DDT was detected in one sample of fluvial sediment. PCBs were not detected in any background sample.

3.6 GROUNDWATER QUALITY

Groundwater quality data for the Fairbanks area indicates that iron and manganese typically exceed federal and state drinking water standards (Nelson 1978, Krumhardt 1982, Downey and Sinton 1990). Although arsenic is commonly detected in groundwater on the Tanana River floodplain, it is typically at concentrations of less than 50 micrograms per liter ($\mu\text{g}/\text{L}$). High natural arsenic concentrations (in excess of 1000 $\mu\text{g}/\text{L}$) have been reported in association with lode mineralization in the bedrock hills north of Fairbanks (Weber 1986). Data for groundwater at Eielson AFB are consistent with these observations.

3.6.1 Background Groundwater Quality

Background groundwater quality data collection efforts at Eielson AFB were described in Section 2.5. Complete analytical results for background samples collected from 1992 to 1994 are provided in Appendix F. A summary of the background data for total metals is provided in Table 3.5. Organic compounds were not detected in background samples. The sample mean, standard deviation, and upper 95% confidence limit on the mean background concentration were calculated for each constituent. Background values for the upland area are not provided because only one upland background well was sampled (Well 38M03 in 1992).

The mean background concentrations of iron ($4400\text{ }\mu\text{g/L}$) and manganese ($1900\text{ }\mu\text{g/L}$) in groundwater at Eielson AFB exceed the secondary maximum contaminant levels (MCLs) for drinking water of $300\text{ }\mu\text{g/L}$ and $50\text{ }\mu\text{g/L}$, respectively. The mean arsenic concentration was $11\text{ }\mu\text{g/L}$, and two samples exceeded the primary MCL of $50\text{ }\mu\text{g/L}$. Arsenic concentrations were consistently higher in two areas: at the southern end of the base near the refueling loop (wells 20M17, 54M02, and 54M04), and west of the power plant cooling pond (wells 54M05 and 54M08) (Figure 2.1).

Seasonal differences in background metals concentrations were evaluated in 1993 by comparing data from samples collected near the peak of and after the major groundwater recharge event, in June and August 1993, respectively. The sampling events were scheduled based on 1992 automatic water-level data; however, the peak of the spring recharge event in 1993 occurred one month earlier. Therefore, the June 1993 samples were collected five weeks after the peak, whereas the June 1992 background groundwater samples were collected two weeks after the peak.

A paired sample *t*-test was performed comparing both June 1992 and June 1993 data with August 1993 data because the June 1992 samples were collected closer to the peak of the major recharge event. The difference in concentrations of metals in pairs of samples from June and August were calculated, and the *t*-test was performed for each constituent to evaluate whether the mean difference was significantly different from zero (see Section 2.5.2).

The *t*-test results are presented in Table 3.6. The *t*-values for the June 1992-August 1993 comparisons do not exceed the critical *t*-value for any constituent, indicating that the mean differences in constituent concentrations are not significant. The *t*-values for differences in calcium and sodium in June 1993 and August 1993 samples exceeded the critical *t*-value, indicating that the mean concentrations of these constituents could be different. However, the mean differences between the June 1993 and August 1993 concentrations for other constituents are not significant. Based upon these results, concentrations of metals in groundwater at Eielson AFB do not appear to exhibit significant seasonal variation.

3.6.2 Major Groundwater Chemistry

Major anion and cation data for samples collected in 1992 were plotted on a trilinear diagram, which incorporates all major constituents and is used to evaluate relationships between different water types (Figure 3.10). Almost all of the samples from Eielson AFB plotted in a very small area, indicating that only one major groundwater type is present in the lowland area of the base. Calcium is the dominant cation, and bicarbonate the dominant anion.

Samples plotting outside the small area on the trilinear diagram are 1-1, 1-2, 20-18, 48-4, and 38-3. Samples 1-1 and 1-2, which have overlapping symbols on the diagram, have about the same cation composition as the other samples, but have a higher concentration of sulfate. These samples were

collected from wells on the west side of the Richardson Highway (Figure 2.1). Groundwater chemistry in this area could be influenced by recharge from Piledriver Slough, especially during periods of high discharge (i.e., in July when snowmelt from the Alaska range is at a maximum). Sample 20-18 has about the same anion composition as other samples but has a greater concentration of sodium and potassium.

Sample 48-4 has a different composition than samples from other lowland wells screened in the shallow portion of the aquifer. It has a higher concentration of sulfate and slightly higher concentrations of sodium and potassium. Groundwater quality in this area could be affected by percolation through the coal piles to the south (hydraulically upgradient) of the power plant.

Sample 38-3 is from the upland area of the base. Well 38M03 is screened in the Birch Creek Schist. The major constituents in the groundwater are also calcium and bicarbonate, but the sample had a significantly higher concentration of sulfate and a slightly different cation composition than samples from the lowland wells.

Figure 3.11 presents Stiff diagrams of the major cation and anion results from intermediate and deep wells at source area ST48 and from the shallow Well 54M05. As stated previously, the chemical composition of Sample 48-4 from shallow Well 48M04 could be influenced by the coal piles near the power plant; therefore, it has not been included in this analysis. A Stiff diagram for Sample 54-5 is provided for comparison to samples from the deeper wells because it is typical of samples from the shallow portion of the aquifer, and Well 54M05 is near source area ST48 (Figure 2.1). These samples were collected to evaluate vertical differences in groundwater chemistry. Well 54M05 is screened from 1.5 m bgs to 7.5 m bgs, Well 48M05 from 11.3 m bgs to 14.3 m bgs, and Well 48M06 from 26.7 m bgs to 29.7 m bgs.

In general, the relative proportions of constituents do not vary significantly with depth in the aquifer; however, the total concentration of dissolved constituents decreases. The major constituents in the groundwater are the calcium and bicarbonate ions. The principal source of carbonate species in groundwater is the dissolution of carbon dioxide from the unsaturated zone between the land surface and the water table; therefore, the concentration of bicarbonate ion decreases with increasing depth in the aquifer. As the concentration of the bicarbonate anion decreases, the concentrations of the calcium and magnesium cations also decrease. The concentration of iron increases and the concentration of sulfate decreases slightly with depth, indicating a more chemically-reducing environment.

3.7 DEMOGRAPHY AND LAND USE

Eielson AFB is within the Fairbanks North Star Borough (FNSB), a county-scale local government. Fairbanks is the urban center of FNSB, and College, North Pole, and Moose Creek are suburban/rural areas within the FNSB. North Pole is about 11 km northwest of the base (population 5000), and Moose Creek is about 4.8 km north of the base (population 510). The TAP crosses the middle of the base for a distance of about 8 km (Figure 2.1).

The land surrounding the base is primarily used for military training associated with Fort Wainwright, an active Army installation located west of Eielson AFB. All lands north and east of the base are owned by the U.S. Army. Northwest of Eielson AFB is Moose Creek and the Chena Flood Project, which is owned by the State of Alaska. The base owns the land west to Piledriver Slough. The land from Piledriver Slough to the Tanana River is in privately held agricultural parcels.

Twenty-Three Mile Slough is a subdivision of residences located southwest of the base. All land west of Tanana River is part of Fort Wainwright and is owned by the U.S. Army.

Approximately 5500 people reside on Eielson AFB. Military housing is located in the central portion of the base, east of Industrial Drive. Eielson AFB includes an elementary school, a junior high school, and a high school that are administered by the FNSB School District. Some children that live off-base also attend these schools.

Groundwater is the only potable water at Eielson AFB and in the communities near the base. The aquifer in this region is used for drinking water supply. Potable water in the main base system is treated to remove iron and sulfate. Groundwater is also used as the principal supply for various other industrial, domestic, agricultural, and fire-fighting uses.

In addition to the base water supply wells and power plant cooling wells described in Section 3.4.4, there are seven small-capacity wells that serve remote areas of the base and 12 additional fire wells. Forty-one private wells are located within a 5-km radius of the base, mostly north-northwest of the base in or near the community of Moose Creek (HLA 1991).

3.8 ECOLOGICAL RESOURCES

An analysis of the biological systems and species present at Eielson AFB is presented in the sitewide biological risk assessment report (USAF 1995e). Eielson AFB consists of a mosaic of 13 habitat types; the major terrestrial and aquatic communities are summarized below.

3.8.1 Terrestrial Communities

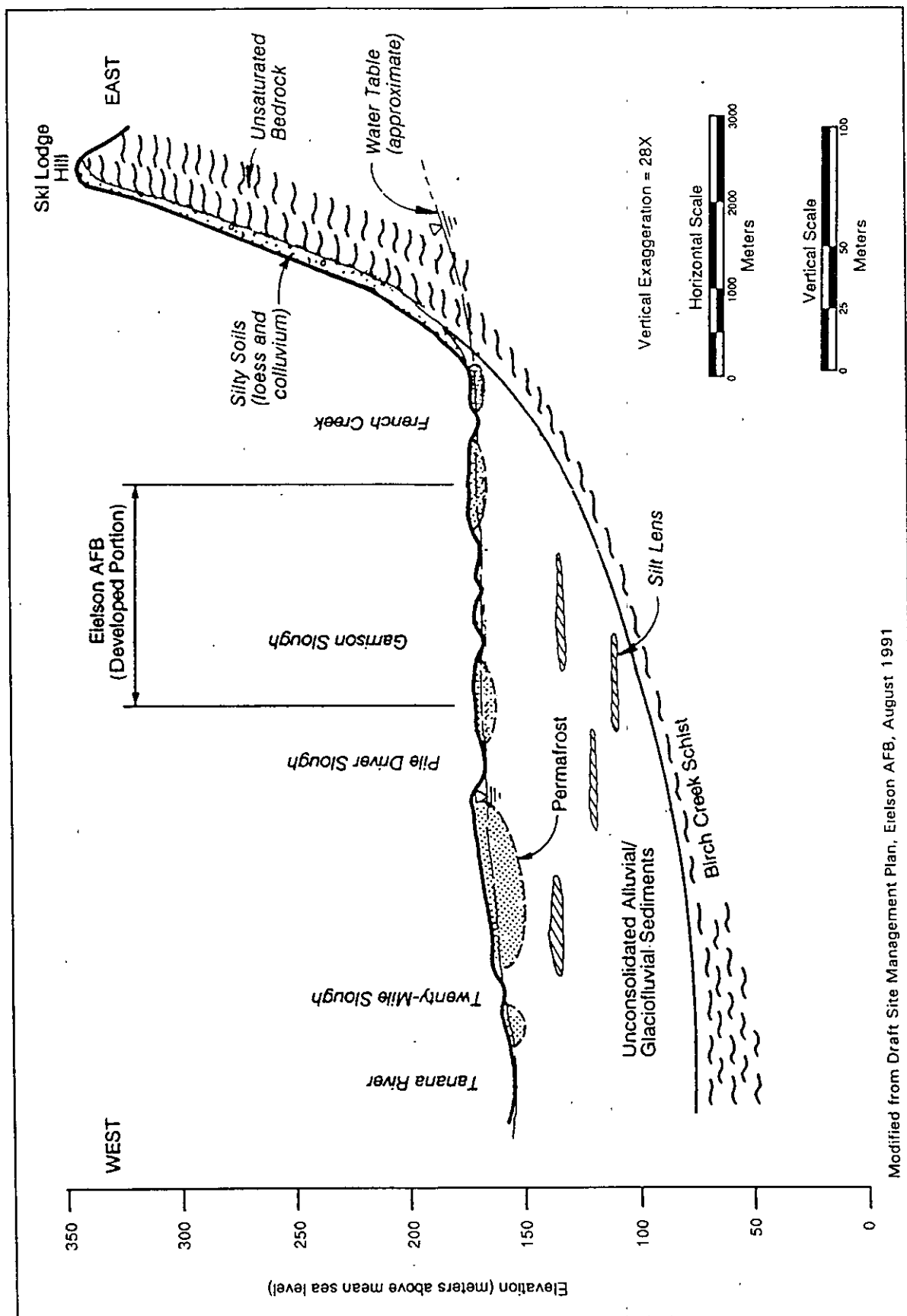
Eight major terrestrial wildlife habitats covering approximately 65 sq km occur at Eielson AFB: black spruce forest, white spruce forest, mature birch forest, young birch forest, balsam poplar forest, willow shrub, old burn, and grassland/mown habitat. The primary wildlife species found in these habitats include black bear, marten, moose, red squirrel, grouse, raptors, snowshoe hare, beaver, and voles.

3.8.2 Aquatic Communities

Aquatic habitat types at Eielson AFB include low-gradient streams, ponds, lakes, and marshes that cover approximately 45 sq km. Species assemblages vary according to physical and chemical characteristics of the surface water. Seventeen species of fish are found on Eielson AFB, including northern pike, rainbow trout, and grayling. Chum salmon (*Oncorhynchus keta*) were observed spawning in French Creek near Quarry Road in August and September 1994. Waterfowl also frequent surface water bodies at Eielson AFB.

3.8.3 Threatened and Endangered Species

No threatened or endangered plant or animal species reside on Eielson AFB. However, the American peregrine falcon (federal listed endangered species) breeds within 80 km of the base. Bald eagles and golden eagles (protected under the Bald and Golden Eagle Protection Act) are occasionally sighted on Eielson AFB.



Modified from Draft Site Management Plan, Eielson AFB, August 1991

FIGURE 3.1. Generalized Hydrogeologic Cross-Section

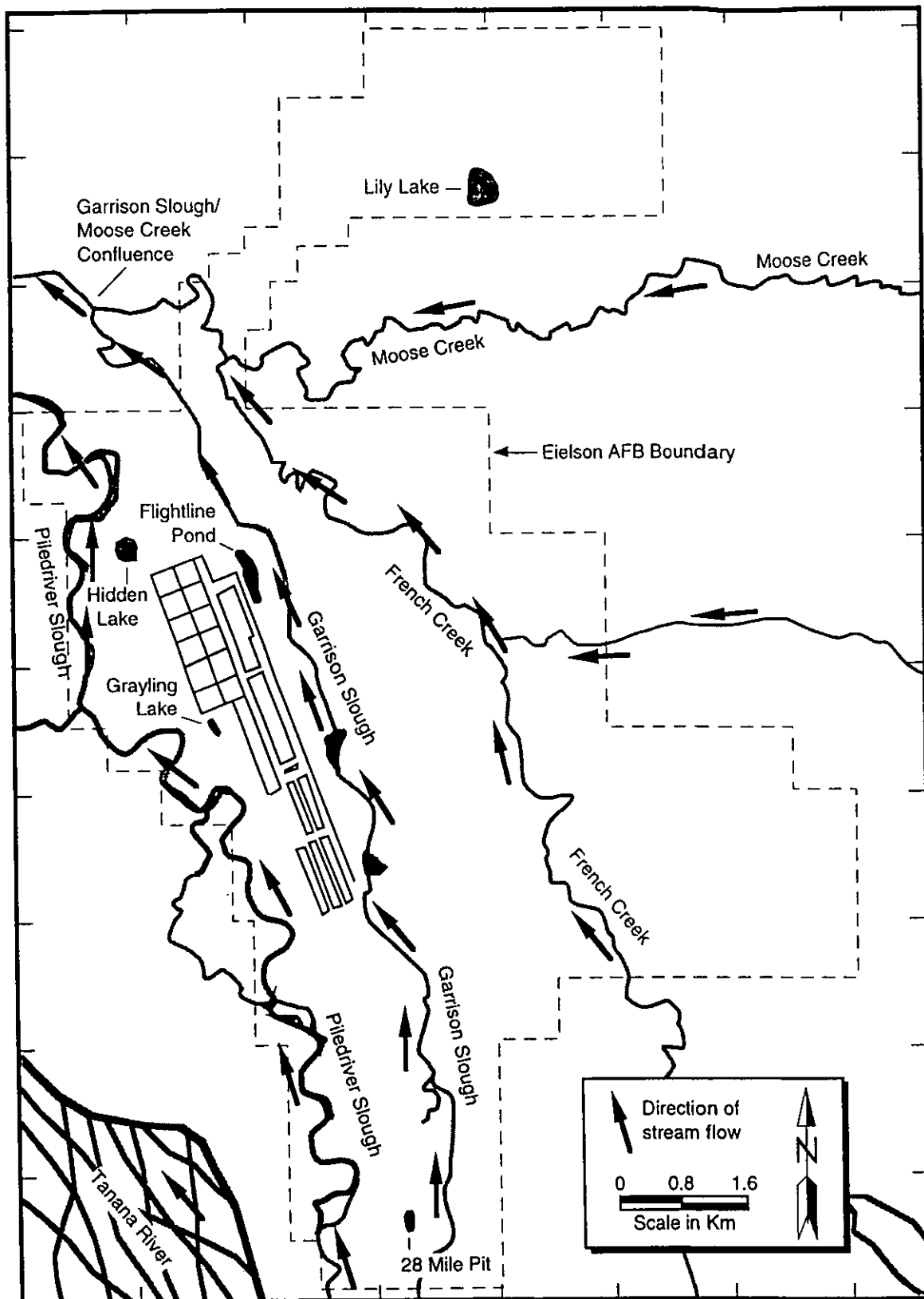





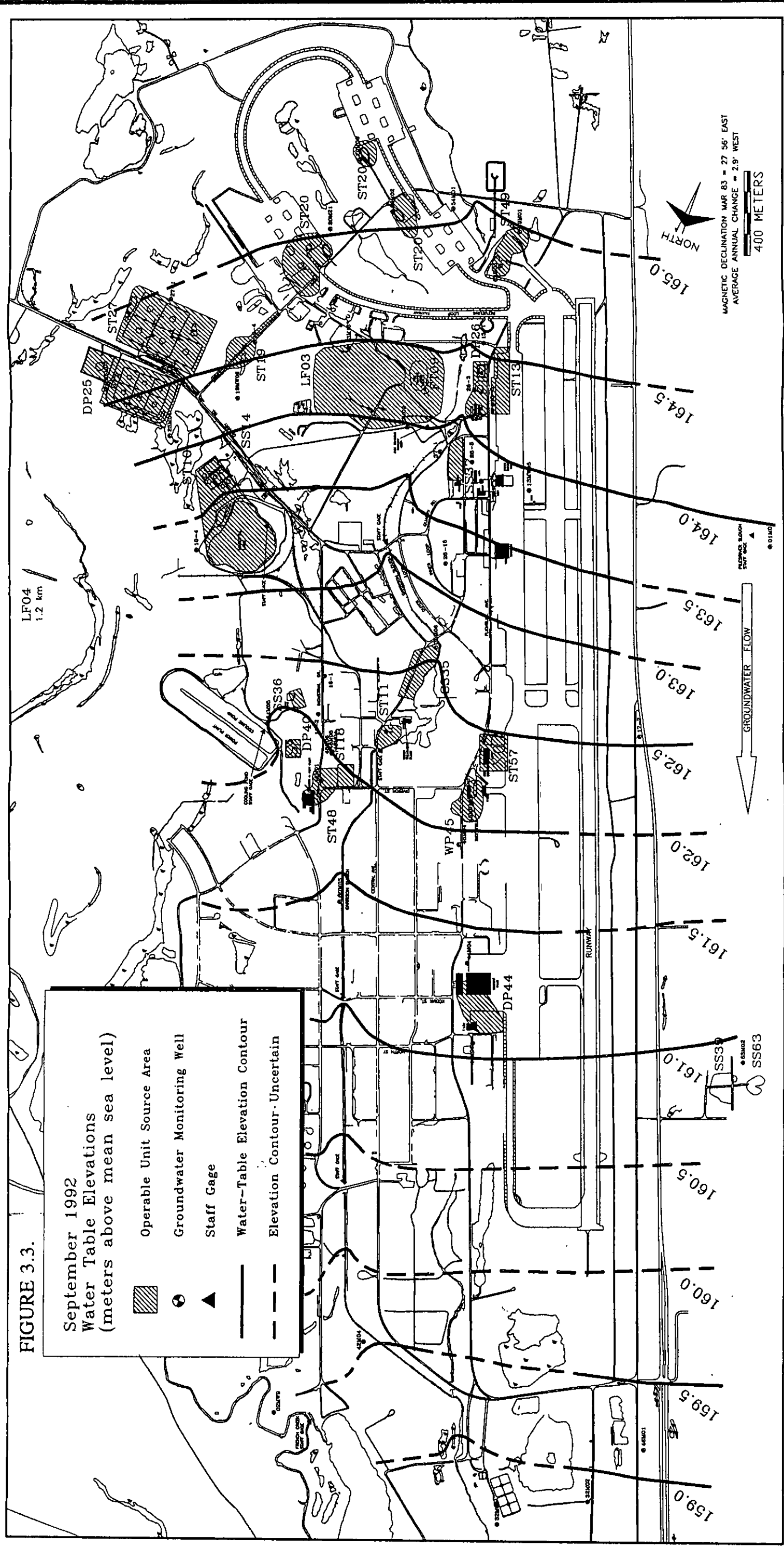


FIGURE 3.2. Surface Drainage Map

September 1992
Water Table Elevations
(meters above mean sea level)

	Operable Unit Source Area
	Groundwater Monitoring Well
	Staff Gage
	Water-Table Elevation Contour
	Elevation Contour-Uncertain



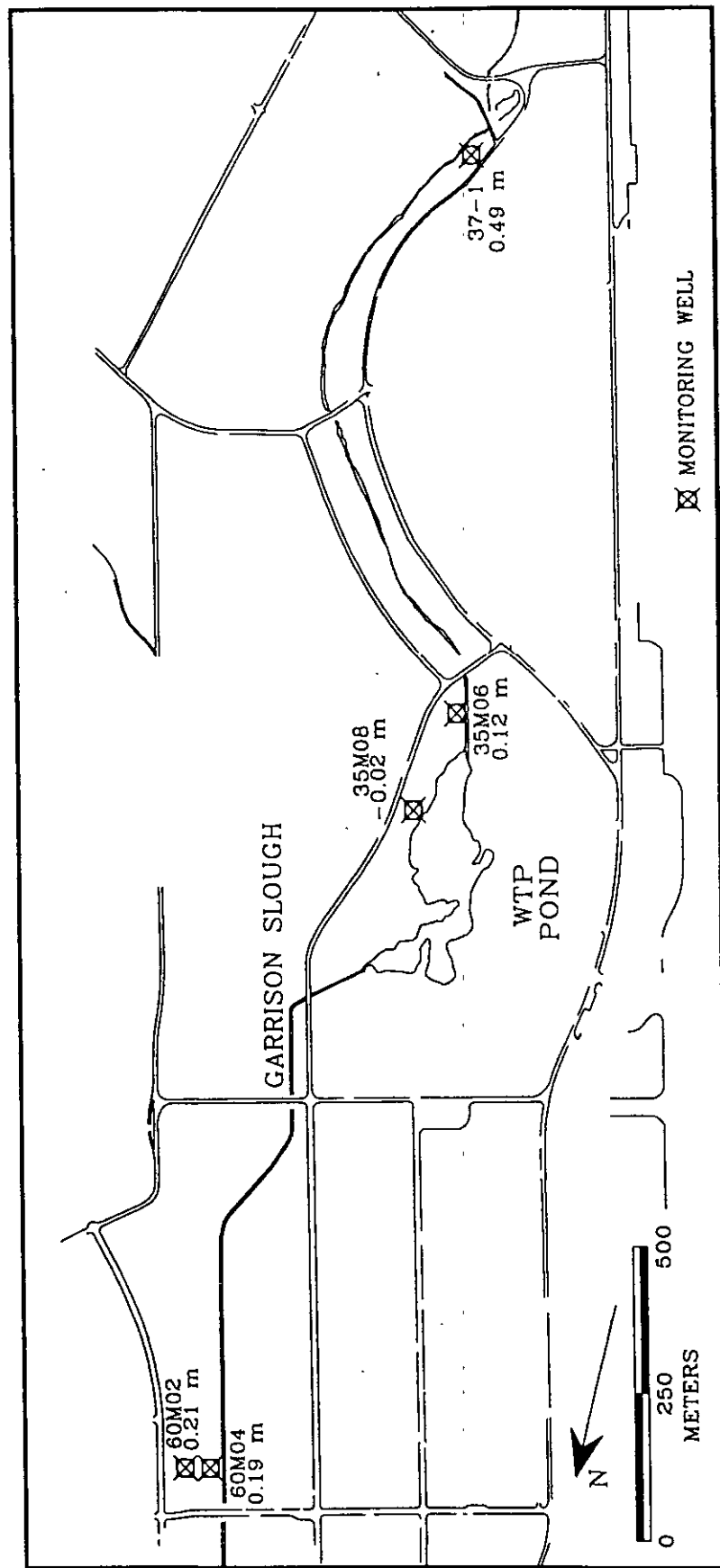


FIGURE 3.4. Height of Water Table Above Garrison Slough, May 1994

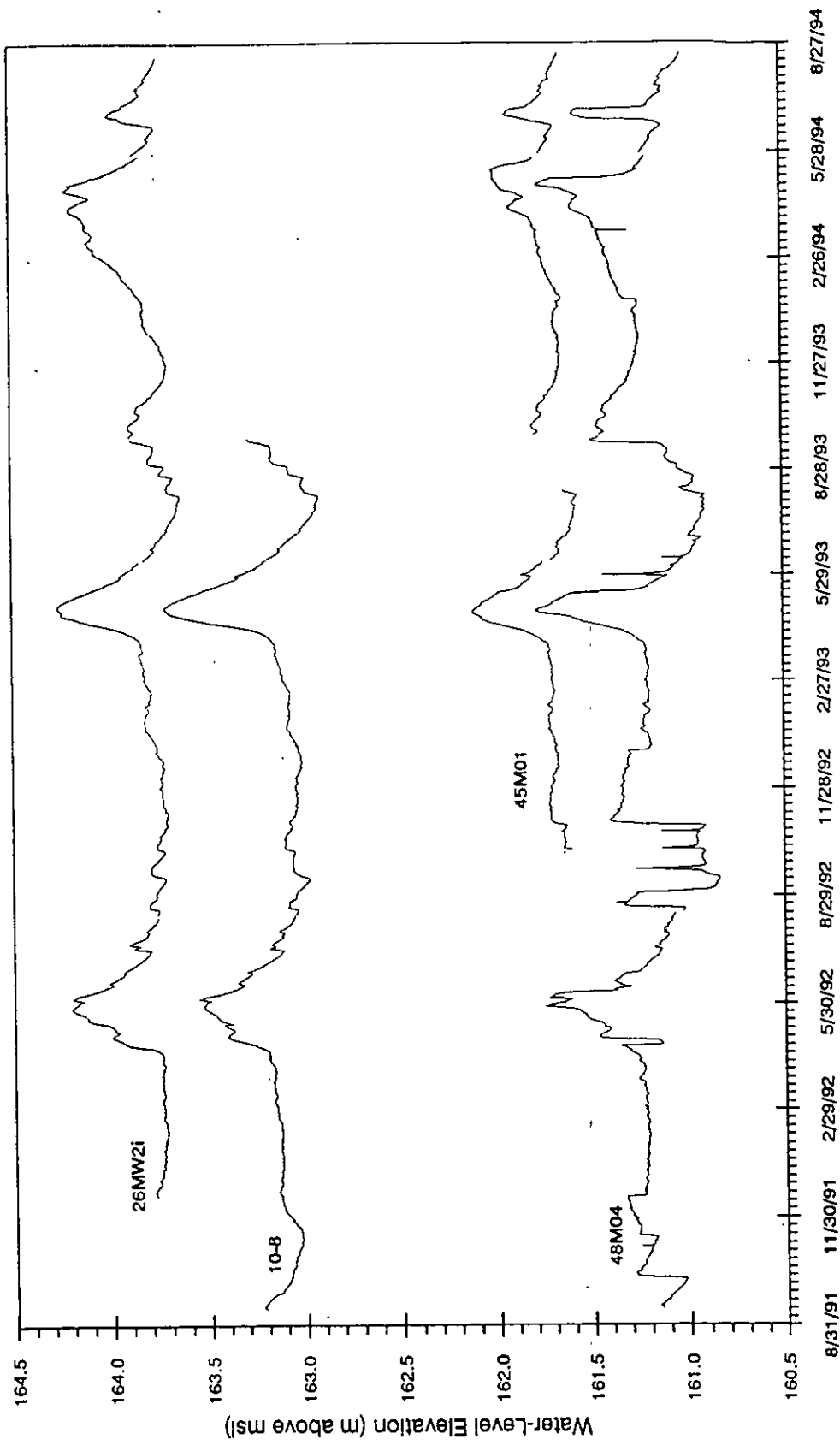


FIGURE 3.5. Typical Water-Level Responses in Wells 26MW2I, 10-8, 45M01, and 48M04

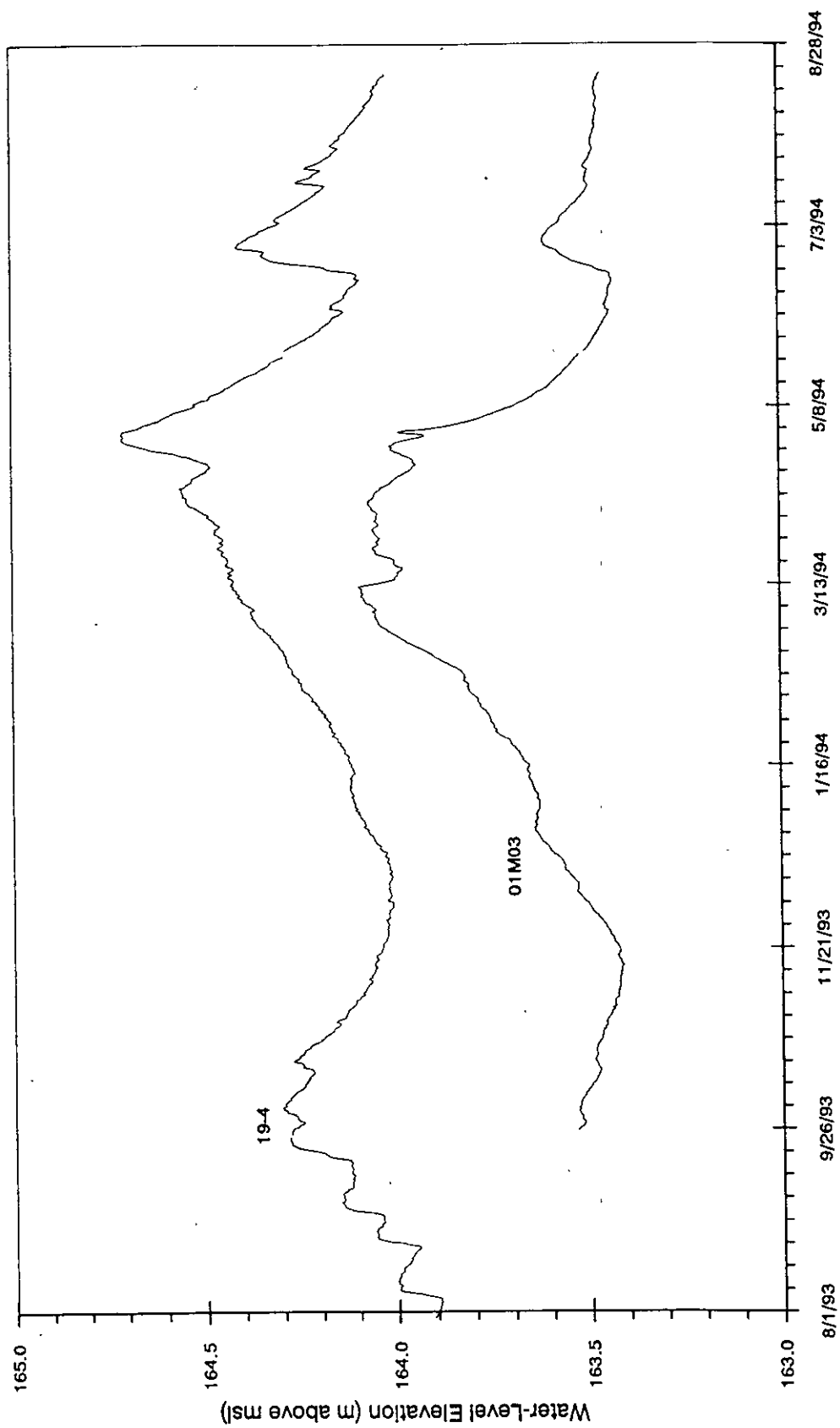


FIGURE 3.6. Comparison of Water-Level Changes at Wells 01M03 and 19-4

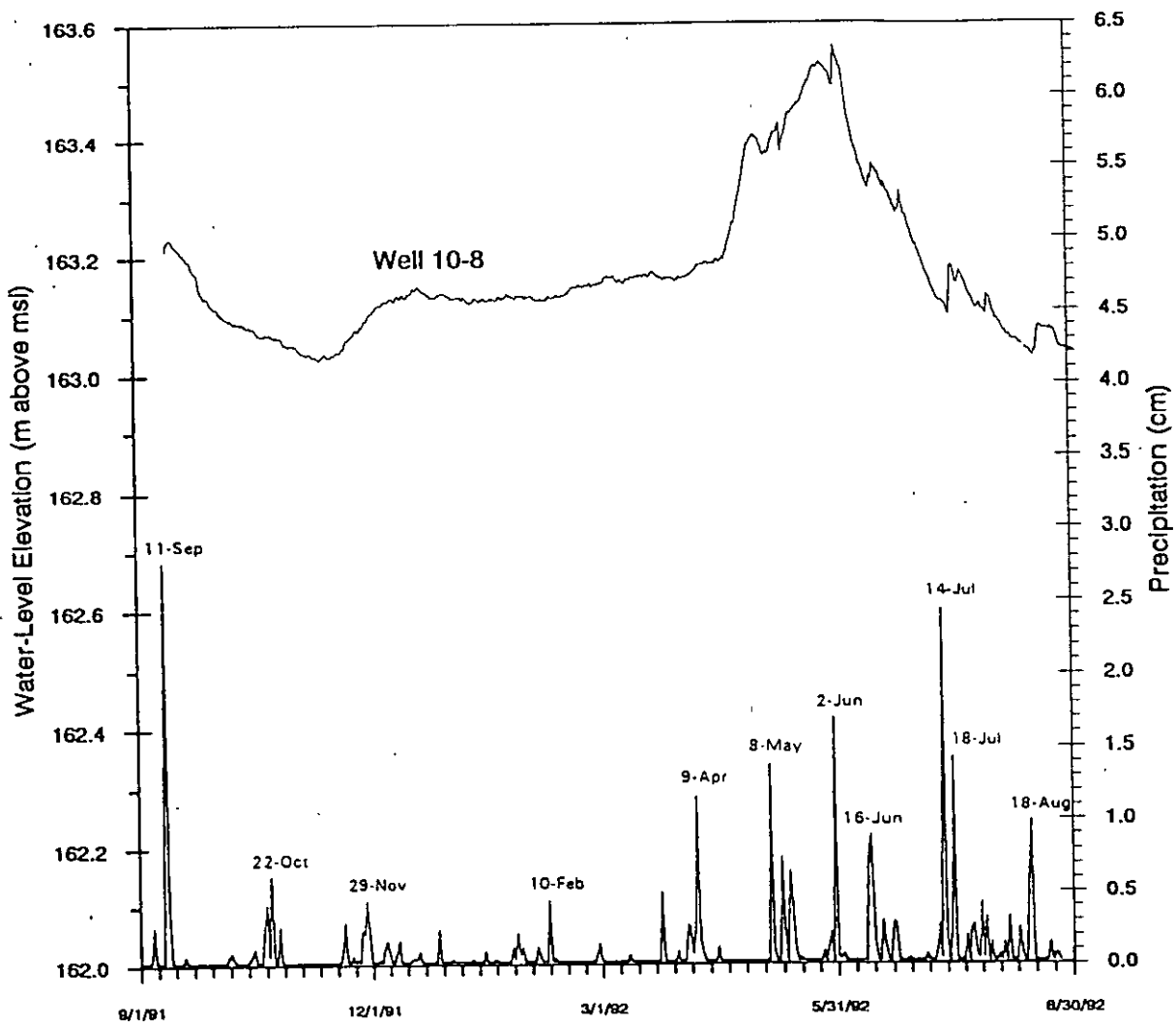


FIGURE 3.7. Precipitation and Water-Level Changes at Well 10-8

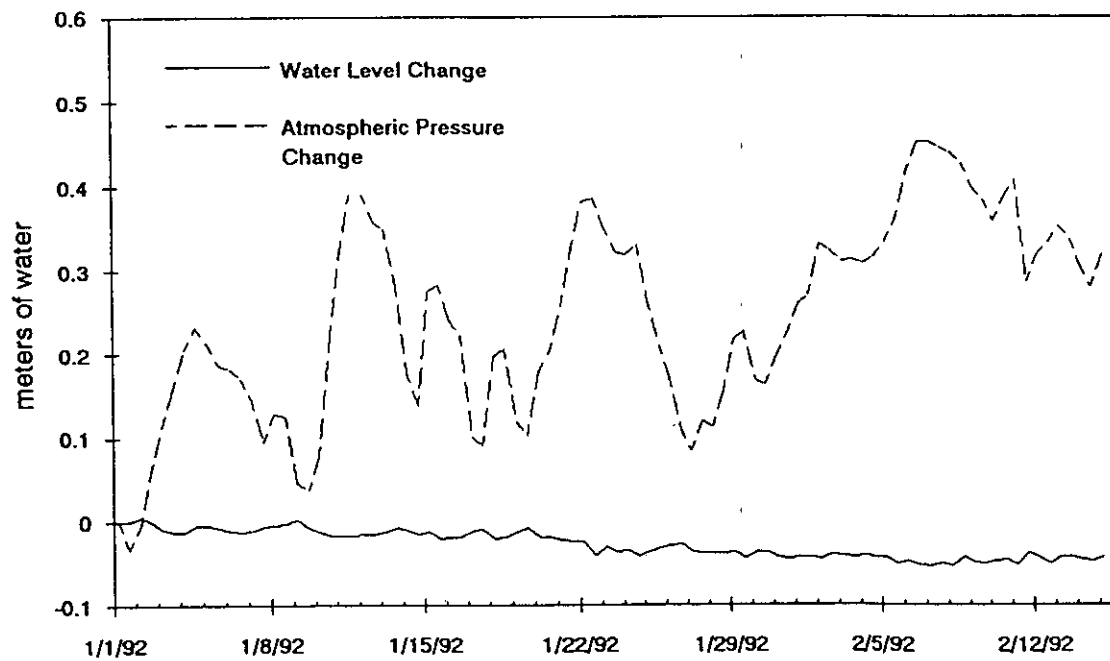
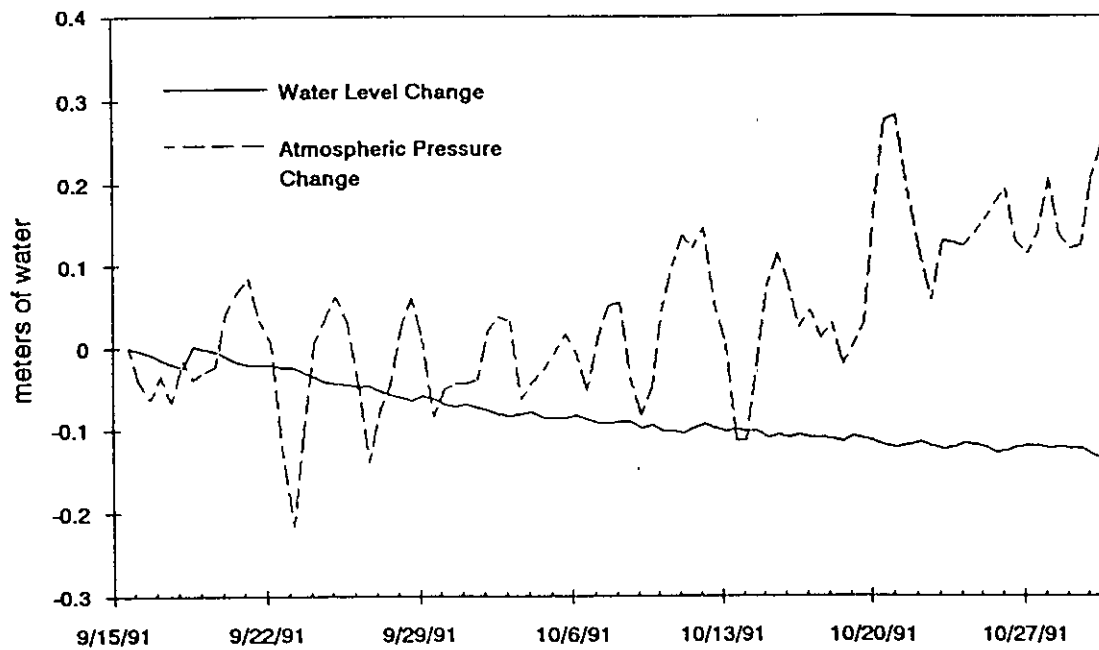


FIGURE 3.8. Changes in Barometric Pressure and Water Level at Well 26-6

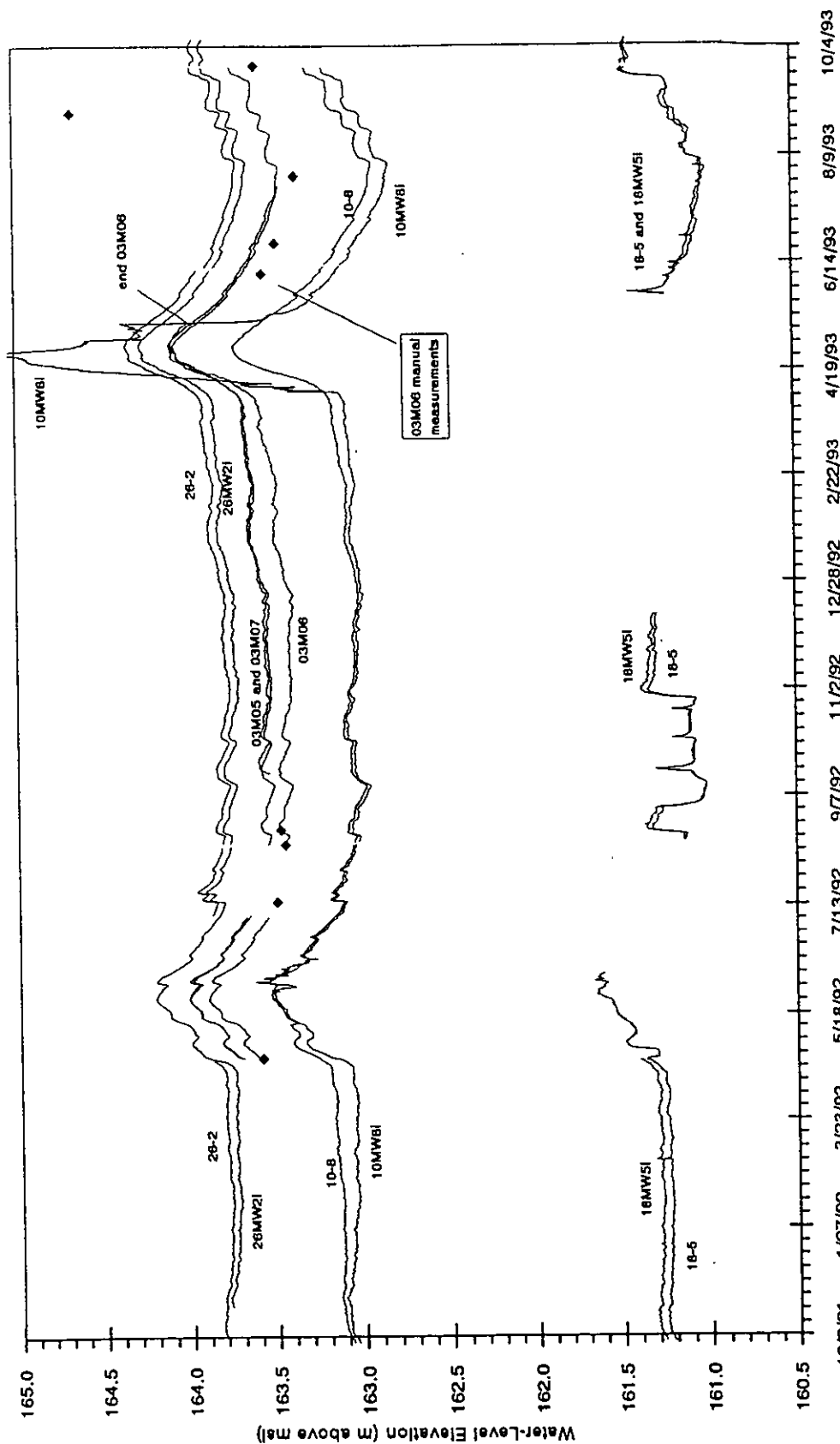
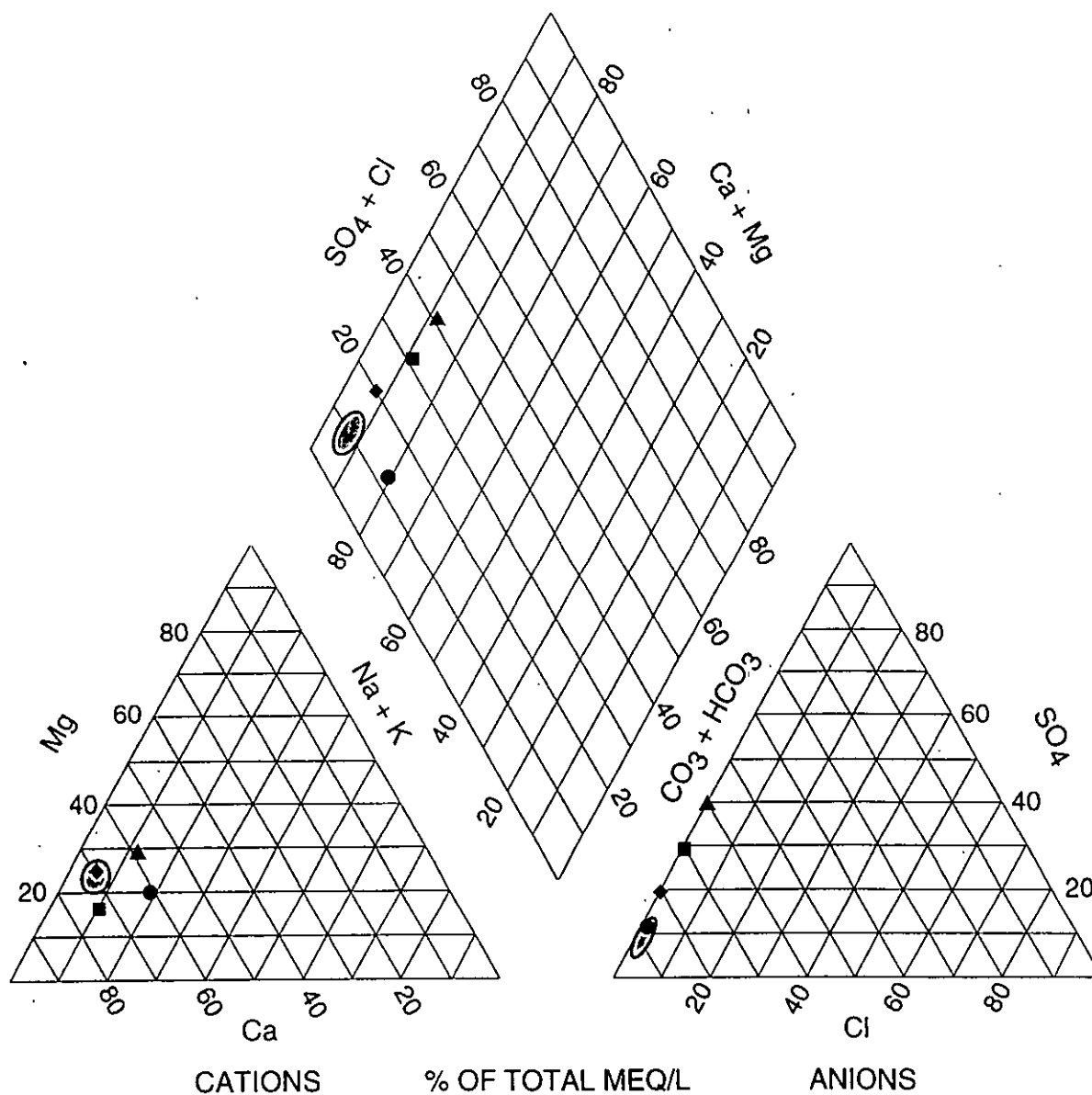


FIGURE 3.9. Water Levels in Wells Completed at Different Depths at Source Areas DP26, ST10, LF03, and ST18



Legend	
Symbol	Sample
◆	1-1, 1-2
●	20-18
▲	38-3
■	48-4
○	5-3 46-1 54-4
○	17-2 46-3 54-5
○	20-21 53-2 54-8
○	27-1 54-2 48-6

FIGURE 3.10. Trilinear Diagram of 1992 Groundwater Samples

Figure 1 is a diagram illustrating the relationship between the concentration of various ions and the concentration of calcium carbonate (CaCO_3) in a water sample. The x-axis represents concentration in meq/L, ranging from 5.00 to 0 on the left and 0 to 5.00 on the right. The y-axis lists ions: $\text{Na}^+ + \text{K}^+$, Ca^{2+} , Mg^{2+} , and Fe^{2+} on the left, and CO_3^{2-} , SO_4^{2-} , HCO_3^- , and Cl^- on the right. A central vertical line at 0 meq/L represents the CaCO_3 concentration. The diagram shows that the concentration of CaCO_3 is equal to the sum of the concentrations of Ca^{2+} and Mg^{2+} (plus a small amount of Fe^{2+}), and also equal to the sum of the concentrations of CO_3^{2-} and HCO_3^- (plus a small amount of Cl^-).

Figure 1 is a diagram illustrating the relationship between the concentration of various ions in meq/L and their corresponding positions on a scale from 5.00 to 0 to 5.00. The ions listed are $\text{Na}^+ + \text{K}^+$, Ca^{2+} , Mg^{2+} , and Fe^{2+} on the left, and CO_3^{2-} , SO_4^{2-} , HCO_3^- , and Cl^- on the right. The diagram shows that Ca^{2+} and Mg^{2+} are concentrated in the middle (0 to 2.50 meq/L), while $\text{Na}^+ + \text{K}^+$ and Cl^- are concentrated at the ends (2.50 to 5.00 meq/L).

3.26

TABLE 3.1. Climate Data for Eielson AFB, Average 1944-1984 ^(a)				
Month	Precipitation ^(b) (cm)	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Temperature ^(c) (°C)
January	2.2	9	-53	-23.9
February	1.6	10	-51	-20.6
March	1.4	11	-46	-12.3
April	1.3	23	-32	-1.7
May	2.0	33	-18	8.3
June	4.1	34	-1	14.3
July	6.5	33	2.2	15.7
August	5.8	31	-6	13.1
September	3.4	28	-15	6.9
October	2.7	20	-38	-4.1
November	2.1	10	-42	-15.9
December	2.2	7	-52	-23.3

- (a) Data from SAIC (1989), Volume II, Appendix A.
(b) Average yearly total for precipitation: 35.2 cm.
(c) Average temperature over 40-year period: -3.6°C.

TABLE 3.2. Estimated Stream Characteristics, August 1987 ^(a)						
Creek	Location	Width (m)	Depth (m)	Substrate	Flow (m ³ /s)	Velocity (m/s)
French Creek	Quarry Road	4.5-6.0	0.6-0.9	Rocky, 2.5- to 7.5-cm diameter gravel	0.56-0.84	0.6-0.9
French Creek	Manchu Road	6.0	0.6-0.9	Gravel with rubble and rocks	0.56-0.84	1.5-3.0
Garrison Slough	Division Street	-	-	Sand, some gravel	0.14-0.28	0.3-0.6
Garrison Slough	Arctic Avenue	2.4-3.0	0.3-0.6	Sand with gravel	0.14-0.28	1.5
Garrison Slough	Transmitter Road	1.8-2.4	0.6-0.9	Sand, silt, and organic matter	0.14	-
Garrison Slough	unnamed road	1.8-3.0	0.3-0.6	Mud and muck	0.028-0.056	<0.3
Moose Creek	Transmitter Road	4.5	0.6-1.2	Sand	0.7-0.84	-
Piledriver Slough	Moose Creek Bluff	10-15	1.2-2.0	Gravel	2.8-5.6	0.9-1.2

(a) Data from HLA 1989.

**TABLE 3.3. Elevation of Garrison Slough and Groundwater
in Adjacent Wells, May 1994**

Well	Height of Groundwater Above Garrison Slough (m)
37M01	0.49
35M06	0.12
35M08	-0.02
60M02	0.21
60M04	0.19

TABLE 3.4. Background Concentrations of Constituents in Soils ^(a)											
Type Sample no. t-value	Statistic	Concentration (mg/kg)									
		Arsenic	Barium	Chromium	Copper	Iron	Lead	Manganese ^(b)	Nickel	Zinc	TPH
Fill 21 1.725	Mean	3.3	57.9	9.5	13.2	9014	3.6	195	12.6	22.7	2.9
	Standard Deviation	1.7	13.0	1.7	2.4	1869	0.6	151	2.3	4.3	3.4
	Upper 95% Confidence Limit	3.9	62.8	10.1	14.1	9718	3.8	252	13.4	24.4	4.2
Fluvial 60 1.671	Mean	13.9	141.2	26.0	44.8	26823	10.6	409	31.9	69.2	2.9
	Standard Deviation	7.6	55.6	10.9	20.6	10604	4.8	196	12.5	27.8	5.8
	Upper 95% Confidence Limit	15.5	153.2	28.3	49.3	29111	11.6	451	34.6	75.2	4.1
Loess 9 ^(c) 1.860	Mean	14.1	184.4	35.2	37.8	25822	8.5	339	32.7	59.4	< 1.8
	Standard Deviation	4.3	17.6	4.2	5.2	2961	0.9	52	4.2	6.1	NA ^(d)
	Upper 95% Confidence Limit	16.7	195.4	37.8	41.0	27658	9.0	372	35.3	63.1	< 1.8

- (a) All background soil samples were collected in 1991.
 (b) 10 fill, 43 fluvial, and 9 loess values biased high due to high matrix spike recoveries.
 (c) Unusually high results for one sample excluded.
 (d) NA Not applicable.

TABLE 3.5 Background Concentrations of Metals in Groundwater ^(a)					
Constituent	Mean (µg/L)	Standard Deviation	Minimum (µg/L)	Maximum (µg/L)	Upper 95% Confidence Limit on Mean (µg/L)
Aluminum	1600	3900	32.5 U ^(b)	18000	2700
Antimony	200 U	NA ^(c)	1.0 U	200 U	NA
Arsenic	11	13	1.0 U	63	15
Barium	130	76	35	420	150
Beryllium	3.0 U	NA	0.814 U	3.0 U	NA
Cadmium	10 U	NA	1.0 U	10 U	NA
Calcium	5000	15000	8000	75000	54000
Chromium	20 U	NA	5.42 U	46	NA
Cobalt	10 U	NA	1.0 U	10 U	NA
Copper	20 U	NA	2.65 U	140	22
Iron	4400	7000	100	33000	6100
Lead ^(d)	5 U	NA	0.6 U	48	6.5
Magnesium	11000	4300	1500	26000	12000
Manganese	1900	1400	20	6500	2200
Nickel	30 U	NA	5.0	77	NA
Potassium	3500	1300	1200	7900	3800
Silver	20 U	NA	1.0 U	20 U	NA
Sodium	4700	2100	1200	9800	5100
Vanadium	30 U	NA	3.84 U	52	NA
Zinc	13	25	3.44 U	120	19

(a) Total metals data from June 1992, June 1993, August 1993, and September, 1994 samples (Appendix F).

(b) U Not detected at or above the given concentration.

(c) NA Not applicable.

(d) Excludes August 1993 lead value from Well 20-1B.

TABLE 3.6. Results of <i>t</i> -Tests for Paired Background Samples			
Constituent	<i>t</i> -value Jun-93/Aug-93 data	<i>t</i> -value Jun-92/Aug-93 data	Critical <i>t</i> -value
Aluminum	-0.255	NA ^(a)	1.753
Arsenic	0.924	0.317	1.753
Barium	0.442	0.186	1.753
Calcium	2.010	0.405	1.753
Iron	-1.115	-0.439	1.753
Lead	0.326	NC ^(b)	1.761
Magnesium	-0.253	-1.401	1.753
Manganese	0.820	1.060	1.753
Potassium	0.302	0.309	1.753
Sodium	2.476	-1.560	1.753
Zinc	0.404	NC	1.753

(a) NA Not applicable; aluminum not measured in 1992 samples.

(b) NC Not calculated because most of the 1992 measurements were below the MDL, and the 1992 MDL was higher than the 1993 MDL.

4.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of contamination originating from identified source areas are addressed in specific OU or SER investigations. Contamination that is not confined to a specific OU or SER is described in this section.

4.1 GROUNDWATER

Contamination of groundwater with fuel-related compounds (primarily BTEX) or chlorinated solvents (TCE and DCE) has been identified at various source areas around Eielson AFB, and a layer of free product is present on the water table at several locations (see Table 1.3). In three areas, plumes of contamination from different source areas have coalesced (source areas ST10/ST14, ST13/DP26, and WP45/ST57). The nature and extent of these groundwater plumes have been delineated in the OU RI reports (USAF 1993d, 1994b, 1995a; Engineering Science 1994). The plumes have either remained the same size or diminished since IRP investigations began in the late 1980s; the contaminants are apparently degrading and dispersing faster than the plumes can expand. Consequently, no contamination is currently migrating off of the base in groundwater, and none is projected to migrate off of the base in the future. The OU RODs require the cleanup of groundwater contamination that poses a potential threat to human health.

Sitewide groundwater monitoring has focused on accomplishing the objectives identified in Section 2.0. The specific objectives of the SWMP varied from 1992 to 1994 as monitoring requirements across the base changed. The results of the annual SWMP are presented in the following sections, with the exception of background groundwater sampling, which is discussed in Section 3.6.1.

4.1.1 1992 Sitewide Monitoring Program

In 1992, sitewide groundwater monitoring was conducted to establish background groundwater quality, and to monitor shallow groundwater quality at the downgradient (northern) end of the base (Section 2.5.1). Complete analytical results are provided in Appendix G (results for background groundwater samples are provided in Appendix F). Background sampling results are discussed in Section 3.6.1.

The North Boundary Wells were sampled for metals, VOCs, and TPH (Table 2.2). The VOC and TPH data were reviewed to identify any anthropogenic organic contaminants. Metals data were compared with site-specific background values. No VOCs or TPH were detected in the 1992 North Boundary Well samples. Metals results are summarized in Table 4.1. Metals concentrations were generally within the range of background values, with the exception of manganese in the sample from Well 51MB5 (11,000 $\mu\text{g/L}$). Iron and manganese were the only constituents that exceeded the state and federal drinking water MCLs of 300 $\mu\text{g/L}$ and 50 $\mu\text{g/L}$, respectively (both are secondary standards). Iron exceeded the MCL in all samples except 51MB1, and manganese concentrations exceeded the standard in all samples. As discussed in Section 3.6.1, high iron and manganese concentrations are typical of background conditions at Eielson AFB.

4.1.2 1993 Sitewide Monitoring Program

The objectives of the 1993 SWMP were as follows:

- Measure background concentrations of metals and arsenic to evaluate seasonal variations in constituent concentrations.
- Sample the North Boundary Wells to monitor shallow groundwater quality at the downgradient edge of the base.
- Collect information from OU-2 source areas to support the Proposed Plan for remedial action.
- Collect additional information from source area LF03 to support the OU-5 RI.
- Collect additional information from three SER sites (LF05, LF06, and SS47) to support recommendations for no further action.

The sampling objective for each well included in the 1993 program is summarized in Table 2.2. Complete analytical results are provided in Appendix G (results for background groundwater samples are provided in Appendix F). Background sampling results are discussed in Section 3.6.1.

North Boundary Wells. Samples were collected from five North Boundary Wells in August 1993 to monitor the quality of shallow groundwater at the downgradient edge of the base. Samples were analyzed for metals, VOCs, and DRO. Analytical results for organic compounds were reviewed to identify any anthropogenic organic compounds, and metals data were compared with background values and to 1992 sampling results. No organic compounds (VOCs or DRO) were detected in the North Boundary Well samples. Metals results are summarized in Table 4.1. The 1993 results are comparable to the 1992 data and to background levels for metals in groundwater at Eielson AFB. As in 1992, manganese in the sample from Well 51MB5 (12,000 $\mu\text{g/L}$) exceeded the range of background values.

OU-2. Samples were collected from wells in source areas ST11, ST18, ST19, and DP26 to support the Proposed Plan for OU-2. Arsenic concentrations in samples from wells in source areas ST11 and ST18 were compared with background values and to concentrations measured in 1991. BTEX concentrations in samples from source areas ST11, ST18, ST19, and DP26 were compared with those measured during the OU-2 RI. Results for each source area are presented below.

Analytical results for arsenic in samples from Wells 11-4 and 18-8 are provided in Table 4.2. The arsenic concentrations measured in 1993 were less than the MCL of 50 $\mu\text{g/L}$, and were within the range of background values for arsenic. These results suggest that arsenic in groundwater at source areas ST11 and ST18 is naturally occurring.

BTEX results for samples from wells 11-3 at ST11 and 18-3 at ST18 are summarized in Table 4.3. Data from the OU-2 RI are provided for comparison (USAF 1993d). BTEX concentrations at ST11 were less than 2 $\mu\text{g/L}$, as they were in 1991. Ethylbenzene and xylene were detected in the sample from Well 18-3 at concentrations of 9.1 $\mu\text{g/L}$ and 61 $\mu\text{g/L}$, respectively. These values are higher than those measured in 1991, but well below the MCLs of 700 $\mu\text{g/L}$ and 10,000 $\mu\text{g/L}$, respectively. A very thin (approximately 2 mm) layer of weathered product was observed in this well.

Well 19-2A, which had the highest benzene concentration measured in groundwater at source area ST19 in 1991, could not be sampled because of frost damage to the well. BTEX results for the sample from downgradient Well 19MW06 are provided in Table 4.3. BTEX compounds were not detected in this sample, suggesting that groundwater contamination from source area ST19 is not spreading.

BTEX and lead results for source area DP26 are presented in Table 4.3. Wells 26-10 and 26-11 were not sampled because they were destroyed during construction activities. Floating product was observed in wells 26-1 and 26-8 at thicknesses of approximately 2 mm and 8 cm, respectively. Total lead concentrations in samples from Wells 26-1 and 26-8 (420 $\mu\text{g/L}$ and 690 $\mu\text{g/L}$, respectively) were similar to those measured in 1991. The dissolved lead concentrations in these samples were much lower (99 $\mu\text{g/L}$ and 55 $\mu\text{g/L}$, respectively), indicating that most of the lead is particulate-associated.

BTEX concentrations in the samples from wells 26-1 and 26-8 were higher than those measured in 1991 (Table 4.3). Benzene, ethylbenzene, and toluene concentrations in these wells exceeded the MCLs of 5 $\mu\text{g/L}$, 700 $\mu\text{g/L}$, and 1000 $\mu\text{g/L}$, respectively. Benzene and xylene concentrations in the sample from Well 26-6, which is located at the lateral edge of a plume of groundwater contamination, were lower than those measured in 1991. Toluene and ethylbenzene were not detected. Traces of benzene, ethylbenzene, and xylene were detected at a maximum concentration of 0.56 $\mu\text{g/L}$ in the sample from Well 26-13, which is located at the distal end of the plume. These results are consistent with the 1991 data. Although the source of contamination at DP26 is still present, the edges of the plume do not appear to have expanded since 1991.

OU-5. Well 03M01 at source area LF03 was sampled for metals to confirm that metals concentrations had decreased from 1988 to 1992 (USAF 1995a). Metals data were compared with concentrations measured in 1988 and 1992, and to background values. Results are presented in Table 4.4. The concentrations measured in June and August 1993 were lower than those measured in 1988, and consistent with those measured in 1992. Barium and iron consistently exceeded the range of background concentrations. Iron and manganese exceeded the state and federal secondary MCLs, which is typical of background conditions at Eielson AFB.

SERs. Results for three SER source areas (LF05, LF06, and SS47) are summarized below. Sampling results are intended to support recommendations for no further action at these source areas. Metals results for samples from source areas LF05 and LF06 were compared with background values. Data for organic compounds (VOCs, SVOCs, pesticides, and PCBs) were reviewed to identify the presence of any organic contaminants. Sampling results from Well 47M05 at source areas SS47 were reviewed to identify contaminants associated with the former fuel spill at the commissary parking lot.

Analytical results for metals detected in samples from LF05 and LF06 are summarized in Table 4.4. Metals concentrations are within the range of background values. Iron and manganese exceeded the state and federal secondary MCLs, which is typical of background conditions. No VOCs, SVOCs, or PCBs were detected in samples from LF05 and LF06. The pesticides beta-BHC and delta-BHC were detected in the sample from Well 06M04 at concentrations of 0.0032 $\mu\text{g/L}$ and 0.0048 $\mu\text{g/L}$, respectively. The presence of beta-BHC in the sample was not confirmed because of an interference on the confirmation column. The pesticide 4,4'-DDD was detected at a concentration of 0.00075 $\mu\text{g/L}$ in the sample from Well 05M01. These results indicate that contaminants are not present in ground water at these source areas, with the exception of trace levels of pesticides.

The sample from Well 47M05 at source area SS47 was analyzed for lead, VOCs, and SVOCs. Lead was not detected. The following VOCs were detected in the sample from Well 47M05: TCE (0.089 $\mu\text{g/L}$), 1,2-cis-DCE (4.7 $\mu\text{g/L}$), and 1,2-trans-DCE (1.9 $\mu\text{g/L}$). SVOCs were not detected. Based upon these results, contaminants resulting from the fuel spill at the commissary parking lot do not appear to have contaminated groundwater at SS47.

4.1.3 1994 Sitewide Monitoring Program

The objectives of the 1994 SWMP were as follows:

- Monitor background concentrations of metals in groundwater.
- Sample the North Boundary Wells to monitor shallow groundwater quality at the downgradient edge of the base.
- Collect information from OU-1 and OU-6 source areas to support the Proposed Plans for remedial action.
- Monitor OU-2 source areas in compliance with the requirements of the ROD.
- Collect additional information from selected source areas in OUs 3, 4, and 5 to support the RI/FS.
- Monitor selected SER sites to support decisions or recommendations for no further action.
- Collect data to complete the characterization of surface water and sediment quality.
- Measure VOC concentrations in Garrison Slough to monitor the impact of adjacent source areas.

The rationale for sampling each well and surface water site is summarized in Table 2.2. Complete analytical results are provided in Appendix G (background groundwater data are provided in Appendix F, and surface water and sediment data are provided in Appendix H). Background groundwater sampling results are discussed in Section 3.6.1, and the 1994 surface water and sediment data are discussed in Section 4.2. Results from the North Boundary Wells, OU wells, and SER wells are discussed in the following sections.

North Boundary Wells. As in 1992 and 1993, samples were collected from the North Boundary Wells to monitor the quality of shallow groundwater at the downgradient edge of the base. Samples were analyzed for metals, VOCs, and DRO. Analytical results for metals are summarized in Table 4.1. Metals concentrations in the North Boundary Well samples were within the background range except for barium in one sample (498 $\mu\text{g/L}$ in 51MB5) and manganese in two samples (7350 $\mu\text{g/L}$ in 51MB1 and 8930 $\mu\text{g/L}$ in 51MB5). As in past years, iron and manganese concentrations exceeded the state and federal secondary MCLs of 300 $\mu\text{g/L}$ and 50 $\mu\text{g/L}$, respectively, which is typical of background conditions at Eielson AFB.

Three organic compounds were detected in the sample from Well 08M01 in August 1994: chloromethane (1.0 $\mu\text{g/L}$), 1,1,1-trichloroethane (2.5 $\mu\text{g/L}$), and toluene (5.2 $\mu\text{g/L}$). A second sample was collected from this well in September 1994 to verify the presence of these compounds; however, they were not detected in the confirmation sample. DRO were not detected in any North

Boundary Well sample. Therefore, organic compounds do not appear to be present in area around the North Boundary Wells.

OU-1. Samples were collected from shallow, intermediate, and deep wells at source area ST48 to monitor BTEX concentrations adjacent to Base Supply Well D. BTEX were not detected in the samples from Wells 48M04, 48M05, and 48M06 (shallow, intermediate and deep, respectively).

One sample was collected from Well 49M05 at source area ST49 to monitor BTEX concentrations. Detected compounds are identified in Table 4.5. TCE and benzene were detected at concentrations of 5.8 $\mu\text{g/L}$ and 3.8 $\mu\text{g/L}$, respectively. TCE exceeds the MCL of 5 $\mu\text{g/L}$. TCE and benzene were both detected at concentrations of 8.2 $\mu\text{g/L}$ in 1993 (USAF 1994b). These data indicate that concentrations of these contaminants have decreased slightly from 1993 to 1994.

OU-2. One sample was collected from a new well (10MW12) at source area ST10 to monitor contaminant concentrations downgradient of Spruce (formerly Hardfill) Lake. Results are presented in Table 4.3. Benzene was detected at a concentration of 10.6 $\mu\text{g/L}$, which exceeds the MCL of 5 $\mu\text{g/L}$. Toluene and cis-1,2-DCE were also detected at concentrations of 0.33 $\mu\text{g/L}$ and 0.30 $\mu\text{g/L}$, respectively. These results suggest that the plume of contamination from source area ST10/ST14 extends downgradient of Spruce Lake.

Samples were collected from wells at source areas ST11 and ST18 to verify the absence of contamination. BTEX were not detected in either sample (Table 4.3). The concentrations of fuel-related compounds (ethylbenzene, toluene, and xylene) at ST18 are lower in 1994 than in past years. Based on these results, fuel-related contamination appears to be absent from ST11 and ST18.

One sample was collected from a new well (19MW07) at ST19 to measure the benzene concentration in the area of former Well 19-2A, which had the highest historical levels of benzene (USAF 1993d). Benzene and ethylbenzene were detected at concentrations of 1.04 $\mu\text{g/L}$ and 0.28 $\mu\text{g/L}$, respectively (Table 4.3). These concentrations are lower than those measured in 1992. A sample was also collected from a downgradient well (19MW06) to monitor the potential migration of contamination; BTEX were not detected. Based on these results, contamination at ST19 appears to be decreasing, and has not migrated downgradient of the source area.

Samples were collected from two wells at DP26 to monitor the extent of a plume of groundwater contamination. Two out of the three new wells installed at the distal end of the plume (26MW17 and 26MW18) were not sampled because they were not completed soon enough to be sampled for this program. BTEX were not detected in the sample from Well 26-6, which is on the lateral edge of the plume of benzene contamination emanating from DP26. New Well 26MW19 on the distal edge of the plume was also sampled. Toluene was detected at a concentration of 0.38 $\mu\text{g/L}$, which is consistent with historical data from distal Well 26-13 (Table 4.3). Based on these results, the contaminant plume from DP26 does not appear to be spreading.

OUs-3, 4, and 5. Samples were collected from source areas WP45, ST27, SS36, SS39/63, and LFO4. Two wells at WP45 (45M04 and 45MW07) were sampled for VOCs to confirm data collected for a natural attenuation study. Results are summarized in Table 4.5. TCE was detected in both samples at concentrations of 4.7 $\mu\text{g/L}$ and 2.0 $\mu\text{g/L}$, respectively. 1,2-dichloroethane and tetrachloroethene were also detected in the sample from 45MW07 at concentrations of 1.2 $\mu\text{g/L}$ and 0.84 $\mu\text{g/L}$, respectively. No fuel-related compounds were detected in either sample. Current and historical results for TCE are presented in Table 4.6. The TCE concentrations appear to be

unchanged from 1992 to 1994, and the August 1994 values agree with the September 1994 data collected for the natural attenuation study.

Samples were collected from wells B-8, B-11, and B-19 at source area ST27 to verify the absence of fuel-related contamination and to monitor lead concentrations. Well B-13 could not be sampled because it was damaged. DRO and GRO were not detected in the ST27 samples (Table 4.7). Total lead concentrations ranged from 38 $\mu\text{g/L}$ to 54 $\mu\text{g/L}$ (Table 4.7). In June 1992, total lead concentrations ranged from 12 $\mu\text{g/L}$ to 22 $\mu\text{g/L}$ (USAF 1995a). The 54 $\mu\text{g/L}$ value in the sample from Well B-8 slightly exceeds the maximum background value of 48 $\mu\text{g/L}$.

Three wells at source area SS36 were sampled to confirm the absence of BTEX, TCE, and metals contamination in groundwater, and to monitor lead concentrations. VOC results are summarized in Table 4.5. The VOCs 1,1,1-trichloroethane, TCE, tetrachloroethene, and toluene were detected at a maximum concentration of 3.1 $\mu\text{g/L}$. Chloromethane was also detected in Well 36M03 at a concentration of 1.2 $\mu\text{g/L}$. Sample concentrations for all of these compounds except chloromethane are below their respective MCLs (there is no MCL for chloromethane). Metals concentrations at SS36 are within the range of background values (Table 4.8). Manganese and iron exceeded the secondary MCLs, which is typical of background conditions.

Five wells at SS39/63 were sampled to verify the absence of fuel-related groundwater contamination. DRO were detected in the sample from 39M01 at a concentration of 0.30 milligrams per liter (mg/L) (Table 4.7). The chromatogram peaks matched the pattern for diesel. GRO were not detected in any sample. The maximum lead concentration was 2.8 $\mu\text{g/L}$ (Table 4.7). Based on these results, evidence of fuel contamination was found in the sample from one well (39M01).

Four wells at LFO4 were sampled to verify the absence of organic contaminants and to monitor metals concentrations. Well 04M01 was not sampled because it was frost-heaved and could not accommodate a sampling device, and Well 04M05 was not sampled because it was dry. Well 04M02 was sampled despite obvious damage from frost-heaving. DRO were detected at concentrations ranging from 0.38 mg/L to 1.30 mg/L in all of the samples (Table 4.7). The analyses quantified chromatogram peaks for compounds with 10 to 24 carbons; however, the peaks did not match the diesel pattern, and the origin of the hydrocarbons is not known. GRO were detected at a concentration of 1.9 mg/L in the sample from well 04MW07 (Table 4.7). The chromatogram peaks do not match the gasoline pattern, but appear to be toluene. Toluene was detected in the sample from this well at a concentration of 290 $\mu\text{g/L}$ (Table 4.5). The compound 3,4-methylphenol was detected at estimated concentrations of 1 $\mu\text{g/L}$ (Well 04M02), 9 $\mu\text{g/L}$ (Well 04M04), 30 $\mu\text{g/L}$ (Well 04M03), and 42 $\mu\text{g/L}$ (Well 04MW07). The compound 2-methylphenol was also detected in the sample from 04MW07 at 10 $\mu\text{g/L}$. Metals concentrations at LFO4 were generally within the range of background values for the lowland area with the exception of arsenic, iron, and barium in several samples (Table 4.8). Based on these results, heavier-weight hydrocarbons, toluene, and phenols still appear to be present in the groundwater at LFO4.

OU-6. Seven wells at WP38 (the ski lodge) were sampled to monitor BTEX and metals concentrations. Wells 38M04 and 38M05 were not sampled because the water level was approximately 260 ft bgs, and the available sampling pump had a maximum depth of about 180 ft bgs. Well 38M07 was not sampled because it was frozen, and attempts to thaw it were unsuccessful. Well 38M06 was also frozen and required thawing; it was sampled after approximately one borehole volume was purged from the well.

Benzene was detected in two of the samples, at 400 $\mu\text{g/L}$ at Well 38M01 and 20 $\mu\text{g/L}$ at 38SLW (the former water supply well) (Table 4.5). Benzene was detected in these wells in 1993 at concentrations of 910 $\mu\text{g/L}$ and 140 $\mu\text{g/L}$, respectively (Engineering Science 1994). The benzene concentrations in wells 38M01 and 38SLW exceed the MCL of 5 $\mu\text{g/L}$, but have decreased since 1993. Metals concentrations were generally higher than the background range for the lowland area, particularly in samples from wells 38M02, 38M06, and 38M16 (Table 4.8). However, these samples were extremely silty. Fuel-related contaminants do not appear to have migrated from the upland area to the wells at the base of the ski hill (wells 38M03, 38M16, and 38M17).

SERs. Samples collected from wells at LF01 and LF05 were analyzed for metals to monitor groundwater quality downgradient of each of the landfills. Results are reported in Table 4.8. Metals concentrations are comparable to the background values. Lead (50 $\mu\text{g/L}$) and iron (35,000 $\mu\text{g/L}$) in the sample from Well 01M04 exceeded the maximum background value; however, these concentrations are comparable to the background values measured in the 1994 samples from adjacent background wells 01M01 and 01M02 (Table F.8).

Samples were collected from wells at sites ST16 and SS47 to verify the absence of fuel-related contamination. Toluene was detected at a concentration of 1.8 $\mu\text{g/L}$ in the sample from Well 16-2 (Table 4.5). This concentration is well below the MCL of 1000 $\mu\text{g/L}$.

No fuel-related VOCs were detected in the wells at SS47 (Table 4.5). Lead was detected at a maximum concentration of 16 $\mu\text{g/L}$ at SS47, which is within the range of background values (Table 4.8). Based on these results, only a trace of fuel-related contamination was found at ST16, and none was found at SS47.

One sample was collected from the Birch Lakes water supply well and analyzed for VOCs and metals. The VOCs chloroform (17 $\mu\text{g/L}$), bromodichloromethane (5.8 $\mu\text{g/L}$), and dibromochloromethane (1.2 $\mu\text{g/L}$) were detected. The water from this well was disinfected (treated) at the wellhead before it reached the sample collection point. These compounds are probably treatment residuals. Metals concentrations were within the range of 1994 background values (Table 4.8).

4.2 SURFACE WATER AND SEDIMENT

The primary contaminants of concern at Eielson AFB are POL products, lead, and spent solvents. Garrison Slough is the surface water body most likely to be contaminated by base activities because of its proximity to 16 potential source areas and because it receives most of the surface runoff from the developed portion of the base. Potential source areas adjacent to Garrison Slough are identified in Table 4.9. Garrison Slough could also receive contaminated groundwater from several source areas, and waste materials could also have been dumped directly into it. Consequently, past investigations of surface water and sediment quality have focused on Garrison Slough. Few surface water and sediment samples were collected from French Creek, Piledriver Slough, or other surface water bodies prior to the sitewide RI.

Results of previous investigations are summarized in Section 4.2.1. Results of the 1993 and 1994 sitewide surface water and sediment investigation are discussed in Sections 4.2.2 through 4.2.5. Complete analytical results for surface water and sediment samples are provided in Appendix H.

4.2.1 Previous Investigations

Surface water and sediment have been sampled periodically at selected locations by BES at Eielson AFB since April 1992. In addition, surface water and sediment samples were collected near various source areas from 1988 through 1990 as part of the IRP. Results of these investigations are summarized below.

Garrison Slough. BES personnel collected surface water samples from Garrison Slough in April 1992, July 1992, September 1992, and April 1993 as part of an ongoing monitoring program. Sediment samples were collected in July 1992. Sample locations are identified in Table 4.10 and Figure 4.1. The surface water samples were analyzed for VOCs; in addition, the July 1992 water samples were analyzed for SVOCs and nitrates. The July 1992 sediment samples were analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals, SVOCs, organochlorine and organophosphorus pesticides, and PCBs (Table 4.10).

Sample results for the July 1992 sample event are summarized in Table 4.10. Arsenic and barium were detected in the TCLP leachate samples generated from Garrison Slough sediment at maximum concentrations of 0.37 mg/L and 2 mg/L, respectively. These concentrations are below the toxic criteria of 5 mg/L and 100 mg/L, respectively. Phthalate esters were found in nearly all the sediment samples at concentrations of less than 1 milligram per kilogram (mg/kg) dry weight. Phthalate esters have been identified as common lab contaminants (EPA 1989); however, no method blank data are available for these samples. Fluoranthene, a PAH, was detected at a concentration of 0.521 mg/kg dry weight in the sediment sample from the Central Avenue location. The chlorinated pesticides, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT, were detected at concentrations of 0.5 mg/kg, 0.04 mg/kg, and 3.89 mg/kg dry weight, respectively, in the sediment sample from GS-1, the most upstream location.

Analytical results for VOCs detected in the surface water samples are summarized in Table 4.11. Benzene and TCE were consistently detected at concentrations of less than 3 µg/L at most of the sampling locations. In addition, 1,2-DCE was detected at the Quarry Street location in July 1992, and ethylbenzene was detected in the sample from the source area FT09 in April 1993. No SVOCs or nitrates were detected in the Garrison Slough water samples.

Surface water and sediment samples were also collected from Garrison Slough from 1988 through 1990 as part of the IRP. Samples were collected near source areas WP32, SS35, SS42, and WP60 during source area investigations. Garrison Slough was sampled at eleven sites in 1990 to characterize its quality. Sample locations and analytical parameters are identified in Table 4.12. Sample locations are shown in Figure 4.1.

Results for compounds detected in surface water and sediment samples collected during the IRP source area investigations are summarized in Tables 4.13 and 4.14. Benzene, DCE, TCE, trichlorofluoromethane, and bis-(2-ethylhexyl)phthalate were detected at concentrations of less than 3 µg/L in surface water samples. Chloromethane was detected at a concentration of 10.9 µg/L at WP32, which is adjacent to the wastewater treatment plant. This compound was most likely derived from the chlorination of water containing suspended solids in the treatment plant. Chlorinated pesticides were detected in one sediment sample, and methylene chloride, a common laboratory contaminant, was detected in one sediment sample (HLA reported that this compound was suspected to be a laboratory contaminant; however, the sample result was not qualified in the data quality assessment process). TPHs were detected in sediment samples at concentrations ranging from 96 mg/kg to 5400 mg/kg dry weight.

Results of the 1990 characterization of Garrison Slough are summarized in Tables 4.15 and 4.16. TCE, DCE, and vinyl chloride were detected at concentrations of less than 1 $\mu\text{g/L}$ in four water samples. Benzene was detected in five samples at a maximum concentration of 7 $\mu\text{g/L}$. One SVOC (4-methylphenol) was detected at a concentration of 2.5 $\mu\text{g/L}$ near LF05. The pesticide DDD was detected at concentrations of less than 0.15 $\mu\text{g/L}$ in eight water samples. Pesticides were detected in all of the sediment samples, and PCBs were detected in 6 of 11 sediment samples, with a maximum of 7.65 mg/kg found at the Arctic Avenue location. No VOCs or SVOCs were detected in sediment samples. TPHs were detected in all sediment samples at a maximum concentration of 1920 mg/kg dry weight.

French Creek. Potential impacts on water and sediment quality in French Creek include source area LF02 and source areas LF04 and WP38 in the upland portion of the base (Figure 1.2). Source area LF02 is located on French Creek near the north end of the base. One surface water and one sediment sample were collected from French Creek near LF02 in 1988; analytical parameters are identified in Table 4.12. Two VOCs (1,2-dichloroethane and 1,1,2,2-tetrachloroethane) were detected at concentrations of less than 0.3 $\mu\text{g/L}$ in the surface water sample (HLA 1989).

Surface water samples were collected in the French Creek lowlands in 1992 during the OU-5 RI to assess whether runoff from source area LF04 was affecting downgradient water quality (USAF 1995a). Samples were analyzed for TDS, metals, and fluoride. Manganese and TDS concentrations in the surface water samples were approximately equal to concentrations in a background groundwater sample collected at LF04. Concentrations of other metals were significantly lower than those in the background groundwater samples, which suggests that surface water in the French Creek lowlands is not affected by LF04. Fluoride was not detected in any sample.

Samples were collected from French Creek at Quarry Road by BES personnel in April 1992 and July 1992. No VOCs were detected at detection limits of 0.3 $\mu\text{g/L}$ to 0.5 $\mu\text{g/L}$ (Major R. Gross, personal communication, June 4, 1993).

Piledriver Slough. One source area (LF01) is located near Piledriver Slough, west of the Richardson Highway (Figure 2.1). One surface water and one sediment sample were collected from Piledriver Slough in 1988; parameters analyzed are identified in Table 4.12. No VOCs or SVOCs were detected in the samples (HLA 1989). In June 1992, water samples were collected from Piledriver Slough by BES personnel as part of an ongoing monitoring program. Samples were collected at the points where Piledriver Slough enters and exits the base. The samples were analyzed for VOCs by EPA Method 503.1; none was detected at detection limits of 0.2 $\mu\text{g/L}$ to 0.5 $\mu\text{g/L}$ (Major R. Gross, personal communication, June 4, 1993).

Lakes and Ponds. Lakes and ponds are located throughout the base. Four water samples were collected in 1991 from Spruce Lake near source area ST10 during the OU-2 RI, three from the surface and one from 0.3 m above the bottom of lake. Sediment samples were collected from three locations along the lake bottom and five locations on its banks. Analytical parameters are identified in Table 4.12. A trace of benzene (estimated at 2 $\mu\text{g/L}$) was detected in one water sample; no other VOCs, SVOCs, pesticides, or PCBs were detected in the surface water (USAF 1993d). Petroleum hydrocarbons were identified at concentrations up to 14,000 mg/kg dry weight in sediment samples from the lake bottom. Petroleum hydrocarbons in Spruce Lake appear to be derived from floating product and contaminants in groundwater migrating from source areas ST10 and ST14.

Lily Lake is a natural lake located at the foot of Engineer Hill (source area ST56), about 4 miles north-northeast of the main gate at Eielson AFB (Figure 2.6). Engineer Hill is a munitions storage and maintenance area. Water samples from drinking water wells at Engineer Hill have been analyzed on a routine basis since 1987. Sample results were obtained from ADEC water quality reports for water supply wells. Organic compounds detected in 1990 and 1991 are benzene (0.4 µg/L), naphthalene (0.9 µg/L), tetrachloroethylene (4.1 µg/L to 7.7 µg/L), and toluene (0.4 µg/L). Groundwater and surface water interactions near Engineer Hill have not been defined, and it is not known whether surface soil is contaminated. Surface water and sediment from Lily Lake had not been sampled prior to the sitewide investigation. It is possible that the lake could be affected by runoff or groundwater seepage from contaminated areas.

Ponds at source areas LF04, LF05, FT08, and ST20 were sampled from 1988 through 1990 during source area investigations (HLA 1989, 1990). Contamination was not detected in any of these samples, except for high metals concentrations in a surface water sample from LF05 (Table 4.15). Arsenic (695 µg/L), beryllium (36.3 µg/L), iron (438,000 µg/L), manganese (18,500 µg/L), and thallium (1,120 µg/L) exceeded primary or secondary MCLs for drinking water in Sample 62S02. A removal action at LF05 was completed in 1994, and subsequent groundwater monitoring has indicated that metals concentrations in this area are not elevated (see Sections 4.1.2 and 4.1.3).

The discharge from the flightline pond at the north end of the runway was sampled for VOCs (EPA Method 503.1) by Bioenvironmental Engineering Services personnel in 1992; none was detected at detection limits of 0.3 µg/L to 0.5 µg/L (Major R. Gross, personal communication, June 4, 1993). This pond has not been sampled for other constituents. No other major surface water bodies are located downgradient of source areas.

Based on the results of the investigations summarized above, sitewide surface water and sediment samples were collected and analyzed in 1993 and 1994. These results are discussed below.

4.2.2 Garrison Slough

The 1993 and 1994 surface water and sediment sampling locations in Garrison Slough are shown in Figure 2.1. The water in Garrison Slough was clear and smelled faintly of sulfur at the point where continuous flow was first observed near source area LF03/FT09. Upstream of this point, stagnant water was covered with a thick sheen. Patches of sheen were observed near the channel banks at Stations GS01, GS02, and GS03, which are located between source area LF03/FT09 and the WTP pond. Fewer patches of sheen were observed downstream of the WTP pond. During the 1993 sample event, the temperature of water in Garrison Slough was 4°C to 7°C upstream of the WTP pond, and approximately 11°C downstream of it. The temperature of water in the slough upstream of the WTP pond was close to the groundwater temperature, which ranged from 4.6°C to 8.1°C in groundwater samples collected from adjacent source areas LF03 and DP26 in August 1993. The water temperature downstream of the WTP pond was higher because of warming during residence in the WTP pond. Sediments ranged from sand and gravel in the center of the channel to fine-grained sand, silt and clay near the banks and in stagnant areas. Abundant decaying leaves were commonly found with fine-grained sediment. Sediment samples were generally collected in finer-grained sediment near the banks, and were not representative of the entire channel.

The 1993 water and sediment samples from Garrison Slough were analyzed for metals, DRO, pesticides, and PCBs (Table 2.2). Water samples were also analyzed for VOCs and GRO. The 1994 water samples were analyzed for VOCs, pesticides, and PCBs. Sediment samples were analyzed for pesticides and PCBs. An uncontaminated background sample could not be collected

from Garrison Slough; therefore, sampling results were compared with background values for groundwater and soil.

GRO, DRO, and PCBs were not detected in any water samples from Garrison Slough. Results for detected parameters are summarized below.

Metals. Analytical results for metals in 1993 water samples are summarized in Table 4.17. Table 4.17 also lists the minimum, mean, and maximum concentrations of total metals measured in background groundwater samples collected at Eielson AFB (Table 3.5). Metals concentrations in Garrison Slough were highest in water samples collected upstream of the WTP pond, which is consistent with a groundwater source to the stream. All metals concentrations were within range of background values for groundwater. Iron and manganese exceeded the secondary MCLs for drinking water of 300 $\mu\text{g/L}$ and 50 $\mu\text{g/L}$, respectively, which is typical of natural background conditions at the base.

Analytical results for metals in 1993 sediment samples are summarized in Table 4.18. Table 4.18 also lists background concentrations of metals measured in soil samples collected from sand and gravel fill, floodplain soils, and loess at the base (Section 3.5). Concentrations of most metals in sediment samples from Garrison Slough were within the range of background soils, with the exception of arsenic at GS06 (Transmitter Road), barium and lead at GS05 (Kodiak Street), and manganese at GS04 (Central Avenue) and GS06.

VOCs. Results for VOCs detected in water samples from Garrison Slough are summarized in Table 4.19. In 1993, VOCs were detected at all stations except GS04, which is immediately downstream of the WTP pond. Benzene was detected at concentrations ranging from 0.62 $\mu\text{g/L}$ to 1.8 $\mu\text{g/L}$ upstream of the WTP pond, and was not detected downstream of the WTP pond. Ethylbenzene was detected at a maximum concentration of 0.086 $\mu\text{g/L}$ at GS05 and GS06. Benzene and ethylbenzene are fuel-related compounds. TCE and cis-1,2-DCE were detected at a maximum concentration of 1.4 $\mu\text{g/L}$ upstream of the WTP pond, and at a maximum concentration of 0.30 $\mu\text{g/L}$ downstream of it. TCE is a chlorinated solvent, and DCE is a degradation product of TCE. Sediment samples were not analyzed for VOCs because none had been previously detected.

In 1994, TCE was detected in the samples from GS01 and GS05 at similar concentrations as those measured in 1993. Dichlorodifluoromethane was detected in the sample from GS00 at a concentration of 2.5 $\mu\text{g/L}$. No other VOCs were detected; however, the analytical detection limits were higher in 1994 than in previous years.

The 1993 and 1994 results for VOCs in Garrison Slough are consistent with data from 1988 through 1993. The VOCs probably originated from contaminated groundwater because they are not likely to persist for long distances in surface runoff. Source area LF03 in OU-5 could be the origin of fuel-contaminated groundwater discharging to the upper end of the slough. Benzene was detected in groundwater at source area LF03 during the OU-5 RI; the source of contamination appears to be either a past fuel spill at the fire training area (FT09), or an upgradient source (USAF 1995a).

Benzene was not detected in surface water samples collected downstream of the WTP pond during this investigation; however, it was detected at Central Avenue and Transmitter Road in 1992 and 1993 (Table 4.11). Ethylbenzene, a less volatile fuel-related compound, was detected at the Kodiak Street and Transmitter Road stations in 1993. It is possible that the fuel-related contaminants originated upstream of the WTP pond, although benzene, which is less dense than water, is likely to

volatilize before being transported long distances in the slough. Source area ST48 in OU-1 is another possible source of contaminated groundwater discharging to the slough downstream of the WTP pond (Figure 4.1). Benzene, toluene, and ethylbenzene have been detected in groundwater at ST48, where hydrocarbon contamination is believed to originate from abandoned subsurface fuel lines (USAF 1994b).

A potential source of solvent-contaminated groundwater to the slough upstream of the WTP pond is source area LF03/FT09 in OU-5. TCE and 1,2-DCE were detected at concentrations of less than 5 µg/L in groundwater samples from LF03 during the OU-5 RI. The likely source of solvent contamination at LF03 is the leaching of landfill debris (USAF 1995a).

Downstream of the WTP pond, source areas ST18 in OU-2 and ST48 in OU-1 are possible sources of solvents in groundwater discharging to the slough. TCE and 1,2-DCE were detected at concentrations of less than 2 µg/L in groundwater samples from ST18 and ST48 (USAF 1993d, 1994b). The source of the solvents at both source areas is not clear, but could be a dry well at source area ST18 (USAF 1993d). This dry well has not been located. Chlorinated solvents could also originate upstream of the WTP pond. Solvents are more dense than water and can be transported longer distances than benzene before volatilizing.

GRO and DRO. GRO and DRO were not detected in surface water samples from Garrison Slough. Sediment samples were not analyzed for GRO. Analytical results for DRO in sediment samples are summarized in Table 4.20. DRO were detected at concentrations ranging from 14 mg/kg to 38 mg/kg dry weight at GS01, GS02, GS03, and GS06.

The slough receives runoff from the most of the developed portion of the base, and the DRO are probably derived from hydrocarbon residues and spills from roads and the runway. In addition, POL wastes were used to oil some roads from 1950 until sometime in the 1980s (CH2M Hill 1982). Sediment contaminated by past runoff from the roads could persist.

Pesticides. Results for pesticides detected in Garrison Slough surface water samples (4,4'-DDD and 4,4'-DDE) are summarized in Table 4.21. Traces of delta-BHC were also detected in samples from GS00, GS01, and GS02 in 1993 at a maximum concentration of 0.0057 µg/L. The compound 4,4'-DDD was detected in all 1993 Garrison Slough samples at a maximum concentration of 0.052 µg/L, and 4,4'-DDE was detected in four of seven Garrison Slough samples at maximum concentration of 0.0035 µg/L. These compounds were not detected in the 1994 samples; however, the detection limit of the analysis was 0.1 µg/L. The average 4,4'-DDD concentration of 0.02 µg/L is about half of the average value measured in 1990 (0.04 µg/L) (Table 4.15).

Results for 4,4'-DDT and its metabolites (4,4'-DDD and 4,4'-DDE) in Garrison Slough sediment samples are summarized in Table 4.22 (all concentrations are reported in dry weight). Other pesticides detected in sediment samples were endosulfan sulfate (47 µg/kg at GS03) and delta-BHC (5.6 µg/kg at GS04) in 1993. Beta-BHC was detected in the 1993 samples from GS03 and GS04; however, its presence was not confirmed because of interference on the confirmation column. In 1993, 4,4'-DDD was detected at concentrations ranging from 9.8 µg/kg to 310 µg/kg in six of seven samples, with the maximum concentration measured at GS01 (Quarry Road). The pesticide 4,4'-DDT was detected at concentrations ranging from 3.4 µg/kg to 170 µg/kg in four of seven sediment samples, and 4,4'-DDE was detected at a concentration of 13 µg/kg in one sample. Results for the 1994 samples were generally higher, with a maximum concentration of 11,000 µg/kg 4,4'-DDD measured at GS01 and 540 µg/kg 4,4'-DDE at GS03 (4,4'-DDT results were qualified as estimates because continuing calibration criteria were not met).

Figures 4.2 through 4.4 show the distribution of pesticide concentrations measured in sediment and water from 1990 to 1994. The variability in sediment pesticide concentrations is probably due to the heterogeneity of the sediment samples and the dynamic nature of the stream bed. Grab samples were collected at each location rather than compositing sediment across the entire channel. In addition, stream flow redistributes the sediment in the channel from year to year. In general, pesticide concentrations are highest upstream of the WTP pond, where the discharge is low and sediments are less likely to be flushed downstream.

Pesticides were widely used on the base prior to 1966, particularly DDT, which was aerially applied. DDT and its breakdown products DDD and DDE are relatively persistent in the environment; consequently, these compounds are likely to be found at low concentrations over a wide area, particularly in stream sediments derived from eroded surface soil.

PCBs. PCBs were not detected in the 1993 or 1994 surface water samples from Garrison Slough. PCB results for sediment samples are summarized in Table 4.22 (all concentrations are reported in dry weight). Aroclor 1260 was detected in six of the 1994 sediment samples at concentrations ranging from less than 13 $\mu\text{g/kg}$ to 55,000 $\mu\text{g/kg}$. Figure 4.5 shows the PCB concentration in sediment with increasing distance from the head of Garrison Slough (near source area LF03/FT09). PCBs were below detection levels upstream of Station GS12. At GS12, the PCB concentration in sediment was 55,000 $\mu\text{g/kg}$. Approximately 1 km downstream, the PCB concentration in sediment dropped by an order of magnitude to 3200 $\mu\text{g/kg}$ (GS07). At GS09, approximately 2.5 km downstream of Arctic Avenue, the PCB concentration dropped by another order of magnitude to 130 $\mu\text{g/kg}$ (GS09). The PCB concentration was on the same order of magnitude (230 $\mu\text{g/kg}$) at Transmitter Road (GS06), the most downstream location sampled.

Sediment PCB concentrations are highest just upstream of Arctic Avenue with the maximum concentration of 55,000 $\mu\text{g/kg}$ measured at the southeast end of Building 2350 (Figure 4.3). The high PCB concentration in sediment at GS12 relative to nearby sampling locations indicates that the a point discharge of PCBs must have occurred near this location. The elevated PCB concentrations downstream of GS12 relative to upstream of it indicate that PCB-contaminated sediment has been transported downstream. A point source of PCBs appears to exist near Building 2350, which houses a vehicle maintenance facility. The building is approximately 30 m southwest of the slough. The PCBs could have been contained in a waste discharge or spill that directly entered the slough from the facility, although there is no record of PCB use or storage at this facility. It is not likely that the contamination resulted from groundwater discharge to the slough because of the extremely low solubility of PCBs, and the limited areal extent of sediment with PCBs exceeding 10 mg/kg. The release(s) appear to have occurred prior to 1990, when HLA measured elevated levels of PCBs at a station near Arctic Avenue, just downstream of Building 2350 (HLA 1991). Elevated PCB concentrations in sediment downstream of Building 2350 indicate that downstream migration of the PCBs has occurred, most likely by the erosion and transport of contaminated sediments.

PCBs are hydrophobic, tend to bind to silt and clay-sized sediment particles, and are extremely resistant to degradation. Transport of PCBs away from their source near Building 2350 could occur by molecular diffusion or by migration of fine-grained contaminated sediments. PCBs could desorb from sediment, diffuse from porewater to the overlying water, be transported downstream, and be adsorbed back onto sediment particles. The rate of transport by this mechanism would be very slow because of the extremely low solubility of PCBs. The erosion and downstream migration of fine-grained sediment will also occur if the current energy is sufficient to cause erosion of the streambed. At GS12, the stream bed was composed of gravel where the current speed was strongest. Near the channel edges, where the GS12 sample was collected, sediment was

composed primarily of fine sand and silt. The critical velocity for the movement of quartz grains at a water depth of 1 m is approximately 20 cm/s to 50 cm/s for fine-grained sand and silt (Blatt et al. 1972). The estimated current velocity in this part of the slough in August 1993 was 30 cm/s, and current velocities estimated by HLA in August 1987 ranged from less than 30 cm/s to 150 cm/s. Based on these observations, it appears that current velocities in Garrison Slough are sufficient to cause erosion and transport of contaminated sediments during at least part of the year.

The limited areal extent of sediment with PCB concentrations exceeding 10 mg/kg indicates that the sediments near the apparent source of contamination are not dispersing quickly (assuming that the spill or discharge occurred prior to 1990). However, the elevated PCB concentrations downstream of Station GS12 relative to upstream of it indicate that downstream transport is occurring. Additional data were collected for the sitewide FS to further delineate the downstream distribution of PCBs in sediment (USAF 1995c). Although the vertical extent of contamination was not measured, it is unlikely to exceed about 50 to 60 cm in the area of highest contamination (between Station GS12 and Arctic Avenue). This estimate is based on the assumption that the vertical distribution of contamination is the result of sedimentary processes in the stream (i.e., erosion, deposition of contaminated sediments, and subsequent burial). The vertical length scale that characterizes these processes is approximately equal to the stream depth, which is about 50 cm in this area. Chemical diffusion in porewater is probably negligible because of the hydrophobic nature of the contaminant.

In summary, the water in Garrison Slough contains low concentrations of VOCs (less than 2 $\mu\text{g/L}$) and pesticides (less than 0.052 $\mu\text{g/L}$). The VOCs probably originate from contaminated groundwater discharging into the slough from adjacent source areas. Another possible source of VOCs to the water is VOC-contaminated sediment; however, no VOCs were detected in Garrison Slough sediment from 1988 to 1990 (Tables 4.14 and 4.16). Garrison Slough sediment is contaminated with pesticides (DDT and its metabolites) along its entire length, and with PCBs from upstream of Arctic Avenue to Transmitter Road (the most downstream station sampled). The pesticides were probably derived from the former widespread application of pesticides across the base. The PCBs appear to be migrating downstream from a point source adjacent to Building 2350, which houses a vehicle maintenance facility.

4.2.3 French Creek

Samples were collected from four locations in French Creek in 1993, and from two locations in 1994 (Table 2.2, Figures 2.1 and 2.4). The water in French Creek was turbid and rust-colored at all sampling locations, and varied in temperature from 3.9°C at the background location to 8.5°C at Quarry Road during the 1993 sampling event.

The 1993 water and sediment samples collected from French Creek were analyzed for metals, DRO, pesticides, and PCBs. Water samples were also analyzed for VOCs and GRO (the background sample was not analyzed for VOCs because they were assumed to be absent). The 1994 samples were analyzed for pesticides and PCBs. Sample results for on-base sampling stations were compared with results for the background sample (Station FCBG), which was collected approximately 8 km upstream of the base. VOCs, GRO, DRO, and PCBs were not detected in water samples from French Creek. PCBs were not detected in the sediment samples. Results for detected parameters are summarized below.

Metals. Results for total metals in surface water samples from French Creek are summarized in Table 4.17. Metals concentrations for downstream stations were generally higher than those

measured at the background location, most likely because the samples from the downstream stations contained more suspended sediment.

Results for metals in sediment samples from French Creek are summarized in Table 4.18. Concentrations of most metals at downstream stations were similar to those measured at the background station. Arsenic, barium, iron, and manganese concentrations were higher in samples from FC02 (downstream of LF04) and FC03 (source area LF02) than they were in the background sample. The sediment samples from FC02 and FC03 were finer-grained than the upstream samples, and the higher concentrations of these metals are probably due to lithologic differences.

GRO and DRO. Gasoline and diesel range organics were not detected in water samples from French Creek. DRO were detected in the sediment sample from FC03 (source area LF02) at a concentration of 11 mg/kg (Table 4.20).

Pesticides and PCBs. Results for pesticides detected in French Creek water samples are summarized in Table 4.21. In 1993, delta-BHC was also detected in the three downstream samples at a maximum concentration of 0.0028 $\mu\text{g/L}$, and dieldrin was detected at a concentration of 0.026 $\mu\text{g/L}$ at FC02. 4,4'-DDD was detected at a maximum concentration of 0.0013 $\mu\text{g/L}$ in water samples from FC02 and FC03. No pesticides were detected in the 1994 water samples; however, detection limits were higher than the concentrations measured in 1993.

Pesticides detected in French Creek sediment samples are summarized in Table 4.22. The pesticide 4,4'-DDD was detected at a concentration of 32 $\mu\text{g/kg}$ in the sediment sample from FC03 in 1994, and 4,4'-DDE was detected at 7.2 $\mu\text{g/kg}$ in the 1994 samples from FC01 and FC03. The 1994 values are higher than the 1993 results from the same locations.

In summary, surface water and sediment from French Creek appear to be relatively free of contamination. DRO were detected at a concentration of 11 mg/kg in sediment adjacent to LF02; they are probably derived from runoff from roads adjacent to the landfill. The pesticides 4,4'-DDD, 4,4'-DDE, and dieldrin were detected at low concentrations at all sampling locations within base boundaries; these compounds are probably derived from the routine application of pesticides.

4.2.4 Moose Creek and Piledriver Slough

Surface water and sediment in Moose Creek and Piledriver Slough were sampled in 1993 only. The characteristics of Moose Creek were similar to those of French Creek, although the water was turbid and brown rather than rust-colored. The water in Piledriver Slough was clear. Water and sediment samples from Moose Creek and Piledriver Slough were analyzed for metals, DRO, pesticides, and PCBs (Table 2.2). Water samples were also analyzed for VOCs and GRO. The water and sediment samples from Moose Creek were also analyzed for SVOCs. GRO, pesticides, and PCBs were not detected in the water samples from Moose Creek and Piledriver Slough. Pesticides and PCBs were not detected in the sediment samples. Results for detected parameters are summarized below.

Metals. Results for metals in water samples from Moose Creek and Piledriver Slough are summarized in Table 4.17. Concentrations of arsenic, iron, and manganese were lower in the sample from Piledriver Slough than in samples from other streams (Garrison Slough, French Creek, and Moose Creek), which probably reflects its origin from the Tanana River rather than the Yukon-Tanana upland.

Results for metals in Moose Creek and Piledriver Slough sediment samples are summarized in Table 4.18. Metals concentrations were similar to those measured in sediment samples collected from other streams, and within the range of background for soils at Eielson AFB.

VOCs. VOCs were not detected in the water sample from Moose Creek. Tetrachloroethylene was detected at a concentration of 0.071 $\mu\text{g/L}$ in the water sample from Piledriver Slough. Tetrachloroethylene was not detected in a groundwater sample collected in August 1993 from a monitoring well located between source area LF01 and Piledriver Slough (USAF 1994d).

GRO and DRO. GRO and DRO were not detected in water samples from Moose Creek or Piledriver Slough. DRO was detected in the sediment sample from Moose Creek at a concentration of 12 mg/kg (Table 4.20).

SVOCs. SVOCs were not detected in the water sample from Moose Creek. Diethylphthalate was detected in the Moose Creek sediment sample at a concentration of 460 $\mu\text{g/kg}$ (Table 4.23). Phthalate esters are used as plasticizers and are also common laboratory contaminants, although this compound was not detected in the associated method blank. Samples from Piledriver Slough were not analyzed for SVOCs.

Moose Creek and Piledriver Slough appear to be almost free of contamination. The trace of tetrachloroethylene detected in Piledriver Slough may be derived from source area LF01, although it was not detected in the groundwater sample collected from the well between LF01 and the slough in August 1993 (Well 01M04). DRO in Moose Creek were probably derived from the adjacent roadway or an upstream source. Diethylphthalate in the sediment sample from Moose Creek is probably due to laboratory contamination.

4.2.5 Flightline Pond and Lily Lake

Surface water and sediment in Flightline Pond and Lily Lake were sampled in 1993. The sediments in both lakes were predominately clay with abundant decaying organic matter. A sheen was observed along the shore of Lily Lake adjacent to the sampling location. Water and sediment samples from Flightline Pond and Lily Lake were analyzed for metals, DRO, pesticides, PCBs, and SVOCs (Table 2.2). Water samples were also analyzed for VOCs and GRO. VOCs, GRO, DRO, PCBs, and SVOCs were not detected in the water samples. PCBs were not detected in the sediment samples. Results for detected parameters are summarized below.

Metals. Concentrations of metals in surface water samples from Flightline Pond and Lily Lake are summarized in Table 4.17. In general, metals concentrations were lower in Lily Lake than in other surface water bodies at Eielson AFB.

Metals concentrations in sediment samples are summarized in Table 4.18. Metals in sediments from Flightline Pond and Lily Lake were similar to those measured in sediment samples from other stations, although the concentrations of many metals were lower in the sample from Flightline Pond.

GRO and DRO. GRO and DRO were not detected in water samples from Flightline Pond and Lily Lake. DRO were detected at concentrations of 41 mg/kg in the sediment sample from Flightline Pond and 11 mg/kg in the sediment sample from Lily Lake (Table 4.20).

Pesticides and PCBs. Delta-BHC was detected in the water sample from Flightline Pond at a concentration of 0.0051 $\mu\text{g/L}$. Pesticides were not detected in the water sample from Lily Lake.

The pesticide 4,4'-DDD was detected at a concentration of 16 $\mu\text{g/kg}$ in the sediment sample from Lily Lake (Table 4.22). Pesticides were not detected in the sediment sample from Flightline Pond.

SVOCs. SVOCs were not detected in the water samples from Flightline Pond or Lily Lake. Ten PAHs were detected in the sediment sample from Flightline Pond, which is located at the north end of the runway. Seven of these compounds were detected at concentrations of less than 1000 $\mu\text{g/kg}$; the highest concentration was 2600 $\mu\text{g/kg}$ (pyrene). Five PAHs were detected in sediment from Lily Lake, with a maximum concentration of 1400 $\mu\text{g/kg}$ (pyrene).

In summary, hydrocarbons were the only contaminants detected in Flightline Pond and Lily Lake. Hydrocarbons in Flightline Pond probably originated from the adjacent runway. The hydrocarbons in Lily Lake are probably derived from roadways and work areas adjacent to Engineer Hill. The small amount of 4,4'-DDD detected in sediment from Lily Lake is probably derived from routine application of pesticides at the base.

4.3 AQUATIC BIOTA

As described in Section 2.7, aquatic biota sampling was conducted in 1994 to accomplish the following:

- Assess the relative contribution of Eielson AFB to contaminants found in fish near the base.
- Determine the spatial distribution of contaminants in fish (i.e., within-site and among-site variability).
- Determine contaminant concentrations at reference sites (i.e., establish background concentrations).

Aquatic invertebrates and macrophytes were also sampled to determine whether contaminant concentrations in fish tissue can be correlated with other ecosystem components. Fish, invertebrate, and macrophyte tissue samples were analyzed for pesticides, PCBs, and PAHs.

Fish were obtained at all locations and consisted primarily of arctic grayling (*Thymallus arcticus*). Northern pike (*Esox lucius*) was the only species obtained at the SS35 location in Garrison Slough and at 28-Mile Pit, and rainbow trout (*Salvelinus namaycush*) was the only species collected in Hidden Lake. Aquatic macrophyte vegetation and benthic invertebrates were obtained at all stream locations except Piledriver Slough. No macrophytes or invertebrates were obtained at the lake areas. Piledriver Slough and the lakes were designated for offsite monitoring only, and fish from these locations were intended to provide background values for comparison to fish caught on the base.

Complete analytical results for aquatic biota samples are provided in Appendix I. Figure 4.6 is a map showing the distribution of total PAHs, total DDT (sum of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT), and total PCBs in fish (average of four values), invertebrates, and aquatic vegetation at each site. These data are summarized and evaluated below.

4.3.1 PAHs

A few PAHs were detected in at least some of the tissues analyzed (Tables 4.24 and 4.25). For ease of comparison and consistency with the analyses performed in the 1993 biological risk assessment (USAF 1995e), PAHs were combined into two groups: those with three or fewer benzene rings and those with more than three rings. Tissue concentrations were then expressed as low-molecular-weight (MW) PAHs or high-MW PAHs by converting wet weight concentrations to molar concentrations, and then summing molar concentrations. PAHs that were not detected in any tissue in any sample were disregarded. The results are shown in Figure 4.7.

The greatest concentration of PAHs (above detection limits) were found in invertebrate samples from Garrison Slough, with peak concentration at the middle Garrison (SS47/Burger King) collection site. The only other site where PAHs were above detection limits was at the Moose Creek/Garrison confluence (low-MW PAHs). Otherwise, off-base results were below detection limits.

Concentrations were highest in invertebrates, followed by macrophyte vegetation, with the lowest concentrations in fish fillets. Low-MW PAHs were detected in grayling caught in the lower Garrison (SS30 vicinity) and middle Garrison locations. High-MW PAHs were detected in pike from the SS35 WTP pond location.

The 1993 high MW-PAH concentrations in fish were similar at all sites resampled in 1994 (middle Garrison, lower Garrison, LF02, and Quarry Road bridge on French Creek), with all concentrations below 0.1 micromoles per kilogram ($\mu\text{mole/kg}$) wet weight. Concentrations of high-MW PAHs were a factor of 2 higher at the Garrison sites in 1994 than in 1993 ($0.2 \mu\text{mole/kg}$ vs. $0.1 \mu\text{mole/kg}$). Both low- and high-MW PAH concentrations were a factor of 2.5 higher in invertebrates sampled in 1994 than in 1993. These differences are well within the sampling and analytical error bounds and do not constitute a difference between years.

Differences among samples within a location accounted for 5% of the total variance in the fish low-MW PAH data set, with differences among locations accounting for the remaining 95% of the variance. For high-MW PAHs, sampling contributed 37% to the overall variance, with differences among locations accounting for the remaining 63% of the variance.

The highest risk to biological receptors from PAH exposures that was identified in the sitewide biological risk assessment report (USAF 1995e) was found at the lower Garrison sampling location. The maximum risk was to shrews consuming insects containing PAH body burdens, with a hazard quotient of 0.02 (the hazard quotient is the ratio of exposure to the lowest observed effects level for a contaminant). Because the relationship between exposure and hazard is linear, increasing the exposure by a factor of 2.5 based on the 1994 data will not produce a hazard quotient approaching 1. Consequently, there is no significant risk to biological receptors from exposure to PAHs at the sites sampled in 1993 or 1994.

4.3.2 PCBs

Aroclor 1260 was the only PCB mixture detected in any aquatic biota sample (Table 4.26). Aroclor 1260 was above detection limits in fish tissues collected from throughout Garrison Slough, from below the confluence of Moose Creek and Garrison Slough, and from the vicinities of LF02 and the Quarry Road bridge on French Creek (Figures 4.6 and 4.7). Aroclor 1260 was detected only in invertebrates from lower Garrison and not at all in aquatic vegetation. No PCB was detected in any biota samples from the control sites off Eielson AFB.

The highest tissue concentrations were in fish, with the highest concentrations at lower Garrison, where all four fish samples were above detection limits (DL), followed by the SS35 area (two of four above DL), middle Garrison (three of four above DL), Garrison/Moose Creek confluence (two of four above DL), and the French Creek sites (one of four above DL at both sites). The 1994 results reproduced the same spatial pattern of concentration as was obtained from the 1993 sampling (USAF 1995e).

The 1994 results from lower Garrison were approximately twice the 1993 results; no PCB was detected from the middle Garrison location in 1993 versus three detections in four of the 1994 samples from that location. The 1993 results for the other locations were approximately 10 times higher than the 1994 averages (Figure 4.8).

Spatial variation in Aroclor 1260 exceeded variation among samples at the same site by a factor of 3. Variation due to analytical sources comprised only 4% of the total variation in the results. Both the pattern of detection among the samples and the lack of hits in the invertebrate samples at any location other than the lower Garrison site supports the hypothesis that the sediment source of the PCBs lies within or just upstream of the lower Garrison sampling location. The higher concentrations in fish tissue at upper Garrison (SS35) compared with those at middle Garrison (SS47) in both 1993 and 1994 could be due to species differences (pike were sampled at upper Garrison, whereas grayling were collected at the other Garrison Slough locations). Detection patterns outside of these areas are consistent with off-site movement of fish that have picked up contaminants from feeding in the lower Garrison area.

The sitewide biological risk assessment (USAF 1995e) identified hazard quotients of 1.5 for shrikes and 0.8 for goshawk at the lower Garrison site. Based on the 1994 data, the hazard quotients for these receptors could be twice the 1993 estimate, putting individuals of both species in jeopardy at this site. Based on the 1994 data, PCB risks at the other sites would not be greater than those presented in the sitewide biological risk assessment (all below 0.5).

4.3.3 DDT and Metabolites

DDT and its metabolites (DDD and DDE) were detected in all samples except vegetation from upper French Creek control, upper Moose Creek, and Chatanika River (Table 4.26, Figures 4.6 and 4.8). Animal tissue samples all contained detectable levels of DDTs, testifying to the widespread occurrence of this xenobiotic in the environment.

The greatest tissue concentrations of DDTs were found in fish samples from Eielson AFB, with the highest concentrations in fish from Garrison Slough. Concentrations in invertebrates were generally about a factor of 2 to 4 below concentrations in fish in the same location, except for the SS35/WTP pond area (upper Garrison) where concentrations in invertebrates were greater than those in fish (Figure 4.8). The fish collected at this location were northern pike, primarily consumers of vertebrates, whereas fish collected at the other Garrison locations were grayling, which consume more invertebrates than vertebrates.

Spatial variation in DDTs concentration in fish accounted for 90% of the total variance (less analytical variation), whereas differences among samples from the same location accounted for only 10% of the variation.

Concentrations of DDT in fish tissue obtained in 1993 (USAF 1995e) were within a factor of 2 of those obtained in 1994 at the same locations (Figure 4.8). 1993 results were higher than 1994

results at the Quarry Road and SS35/WTP pond locations, approximately the same at the LF02 site, and lower at the middle and lower Garrison sites.

The hazard quotients for DDT exposure found from the 1993 data at the middle and lower Garrison sampling sites were 0.009 for shrikes at lower Garrison and 0.003 at middle Garrison (USAF 1995e). Using the 1994 data, the hazard quotients would be no more than 0.02 at these sites, well below significant risk levels. The hazard quotient to goshawk at SS35 was 0.02 based on 1993 data (USAF 1995e); based on the 1994 data, the hazard quotient would be approximately half that level. Consequently, DDTs at Eielson AFB do not pose a significant hazard to terrestrial vertebrates from direct toxicity.

4.4 SUMMARY

The sitewide RI included investigations of contamination in groundwater, surface water, sediment, and aquatic biota. Results of sitewide groundwater monitoring indicate that no contaminants are present in shallow groundwater at the north (downgradient) edge of the base in the area of the North Boundary Wells. Monitoring results have supported recommendations for no further action at some source areas. In general, sampling in areas of known contamination has indicated that identified plumes are not expanding, or that contaminant levels are either constant or are decreasing (however, not all identified plumes were sampled under the sitewide monitoring program between 1992 and 1994). Monitoring at source area ST10 in 1994 indicated that the benzene plume extended downgradient of Spruce Lake. Surface water and sediment contamination was largely confined to Garrison Slough; only traces of contamination were found in other surface water bodies (French Creek, Moose Creek, Piledriver Slough, Flightline Pond, and Lily Lake).

Based on 1993 and 1994 data, the water in Garrison Slough contains low concentrations of VOCs (less than 2 $\mu\text{g/L}$) and pesticides (less than 0.06 $\mu\text{g/L}$). Garrison Slough sediment is contaminated with pesticides (DDT and its metabolites) at numerous locations along its entire length. The VOCs probably originate from contaminated groundwater discharging into the slough from adjacent source areas, and the pesticides were probably derived from the former widespread application of pesticides across the base.

PCBs were measured in Garrison Slough sediment from the area just upstream of Arctic Avenue to Transmitter Road (the most downstream station sampled). The maximum concentration of Aroclor 1260 in sediment was 55,000 $\mu\text{g/kg}$. The PCB concentration dropped by an order of magnitude approximately 200 m downstream, and by another order of magnitude approximately 700 m downstream. A point source of PCBs appears to exist in Garrison Slough south of Arctic Avenue near Building 2350. The PCBs could have been contained in a waste discharge or spill that directly entered the slough. Elevated PCB concentrations in sediment downstream of Building 2350 indicate that downstream migration of the PCBs has occurred, most likely by the erosion and transport of contaminated sediments.

PAHs, pesticides, and PCBs were detected in aquatic biota samples collected from Garrison Slough. A strong spatial relationship exists between PCB concentrations in sediment and fish, that is, the highest concentrations in sediment were measured in Garrison Slough near Arctic Avenue, and the highest concentrations in fish tissue were measured in fish caught in the same reach of the slough. Additionally, concentrations of PCBs in fish tissue decreased at points downstream of Arctic Avenue and were approaching background in tributary streams upstream of the Garrison Slough-Moose Creek confluence. Concentrations in both sediment and tissue were orders of magnitude

lower at other sampling locations. Therefore, it is assumed that a complete exposure pathway exists from the sediment to the fish in lower Garrison Slough, and that the high concentrations in fish tissues are a direct result of exposure to the contaminated sediment.

Contaminant concentrations in 1994 aquatic biota samples were compared with those measured in 1993 to assess whether the conclusions of the sitewide biological risk assessment were verified. Using the 1994 data, the hazard quotients for PAHs and DDTs were still well below 1. The hazard quotients for PCBs were twice the 1993 estimates for biological receptors at lower Garrison Slough (3.0 for shrike, and 1.6 for goshawk). Hazard quotients for PCBs were unchanged for receptors at other locations.

Contaminant concentration data for surface water, sediment, and aquatic biota were used in the sitewide baseline and biological risk assessments to evaluate the nature and magnitude of risks to human health and the environment resulting from the contamination (USAF 1995d, 1995e).

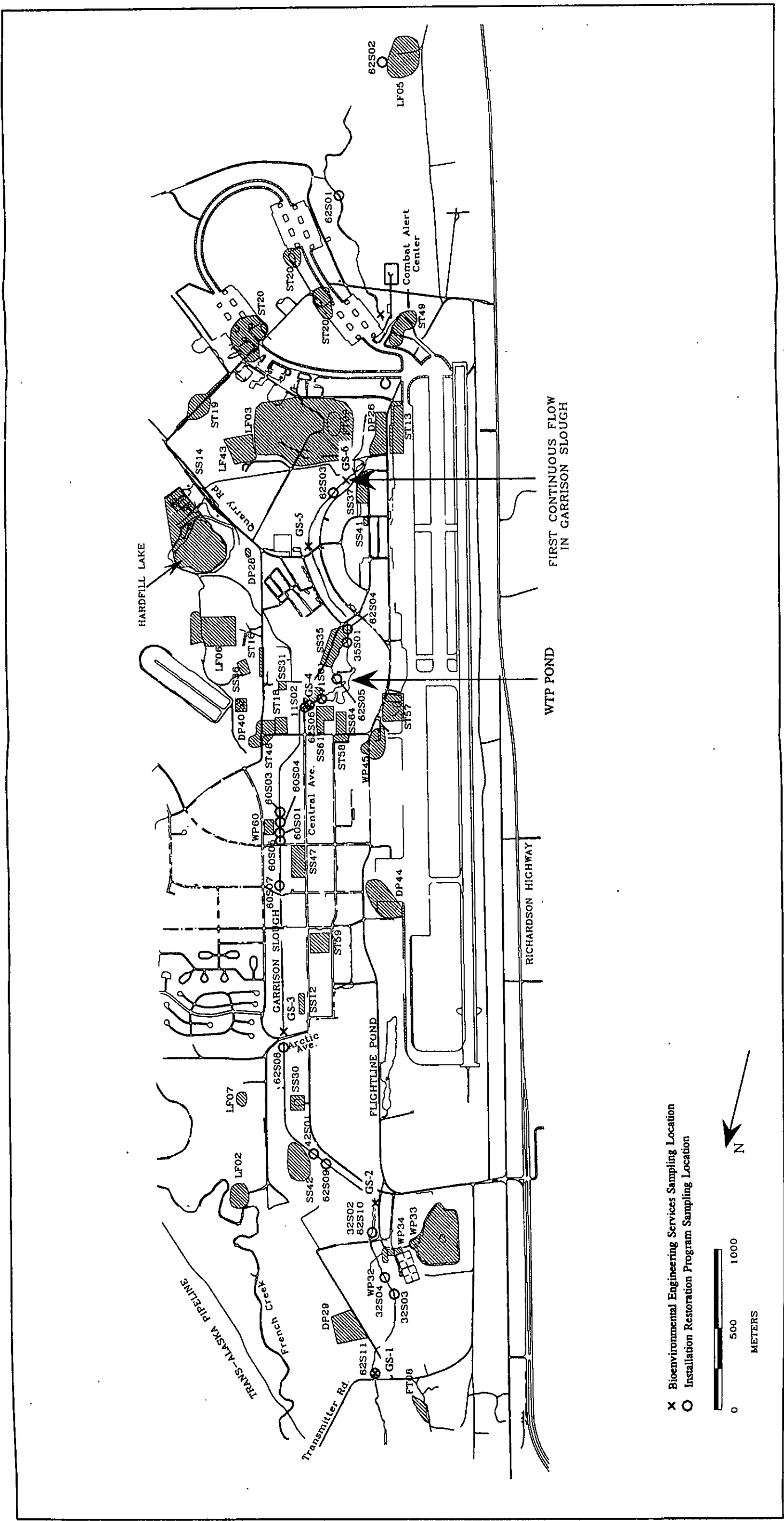


FIGURE 4.1. Surface Water and Sediment Sample Locations from Previous Investigations

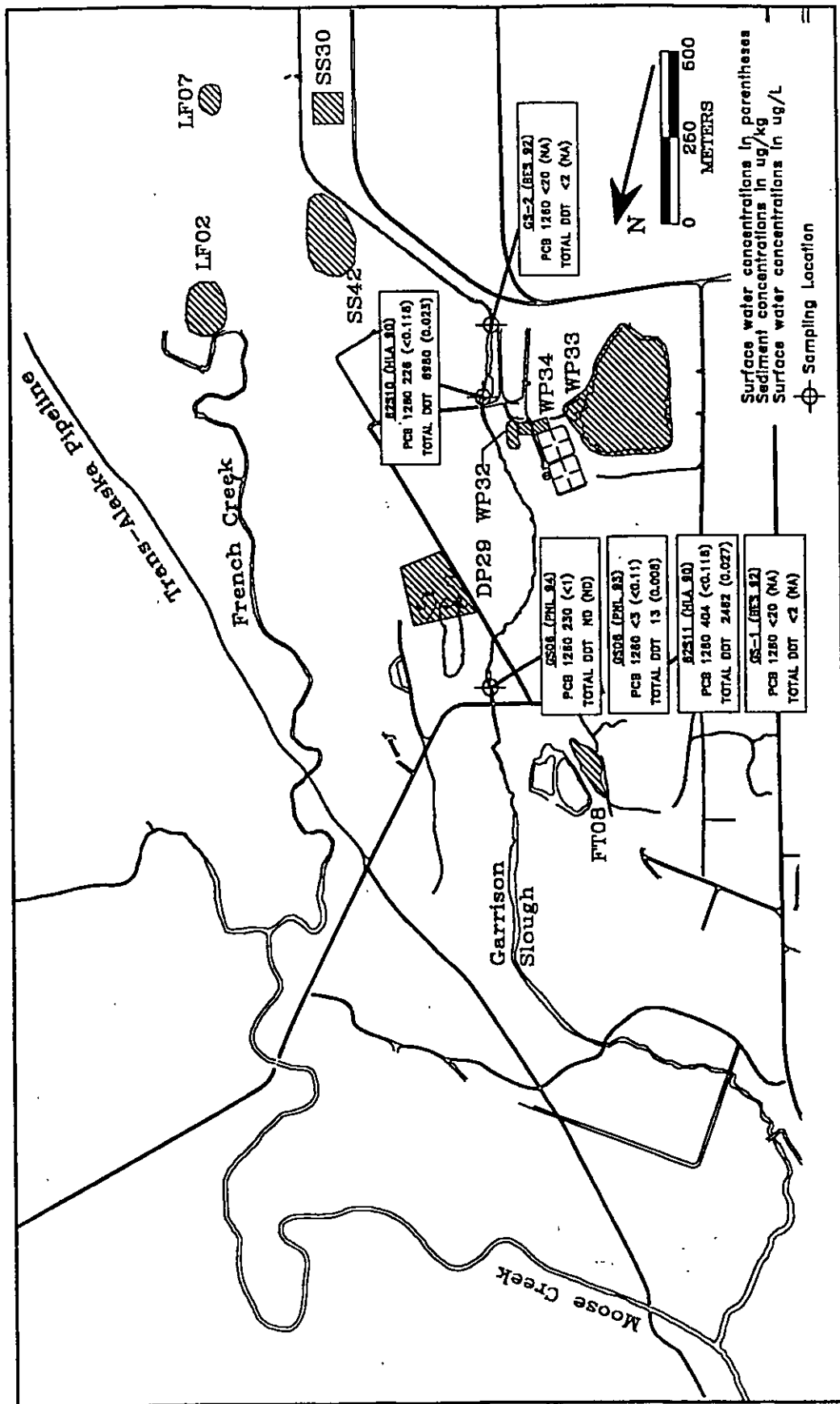


FIGURE 4.2. PCBs and Total DDT in Sediment and Water Samples (North)

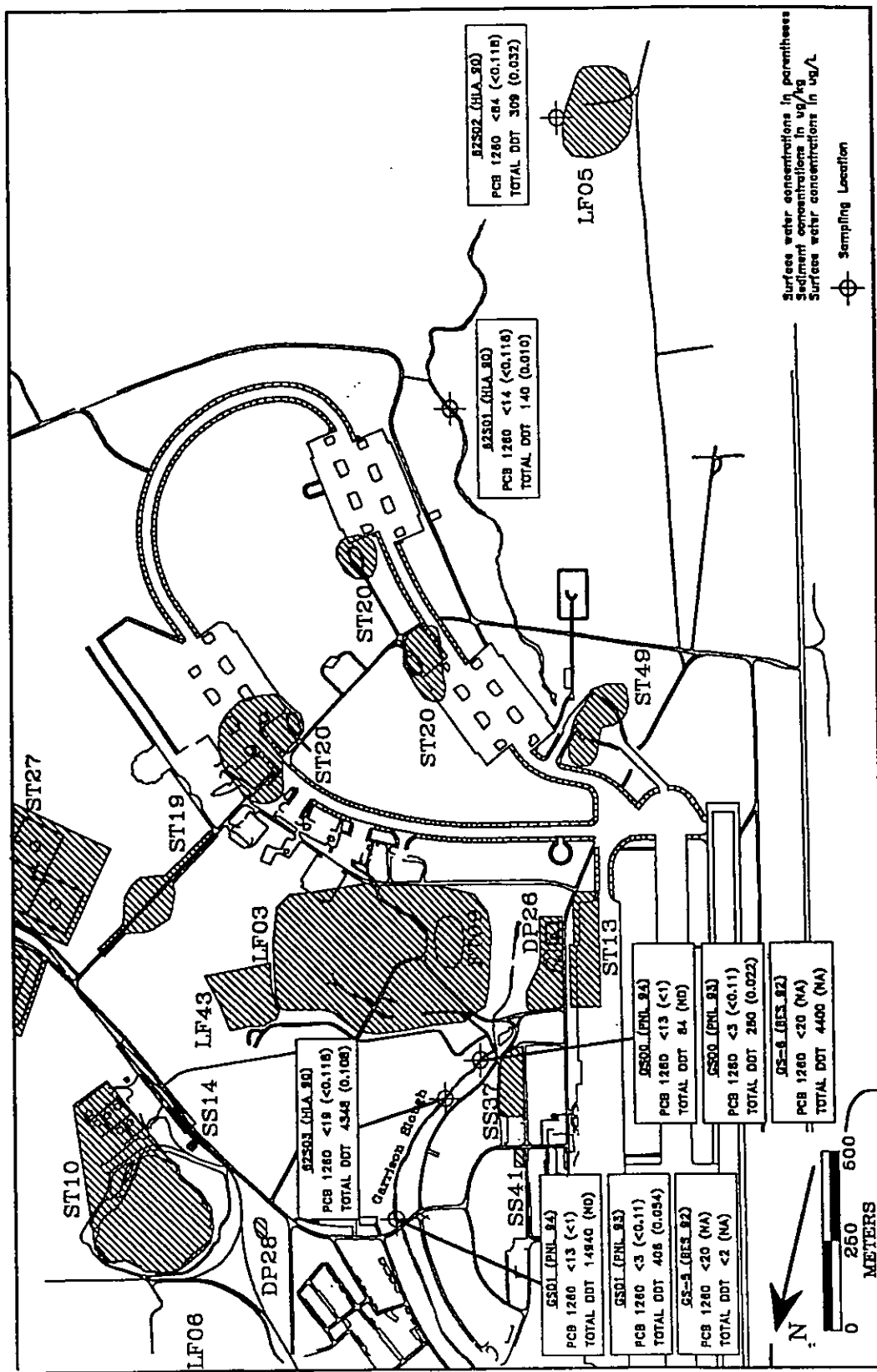


FIGURE 4.4. PCBs and Total DDT in Sediment and Water Samples (South)

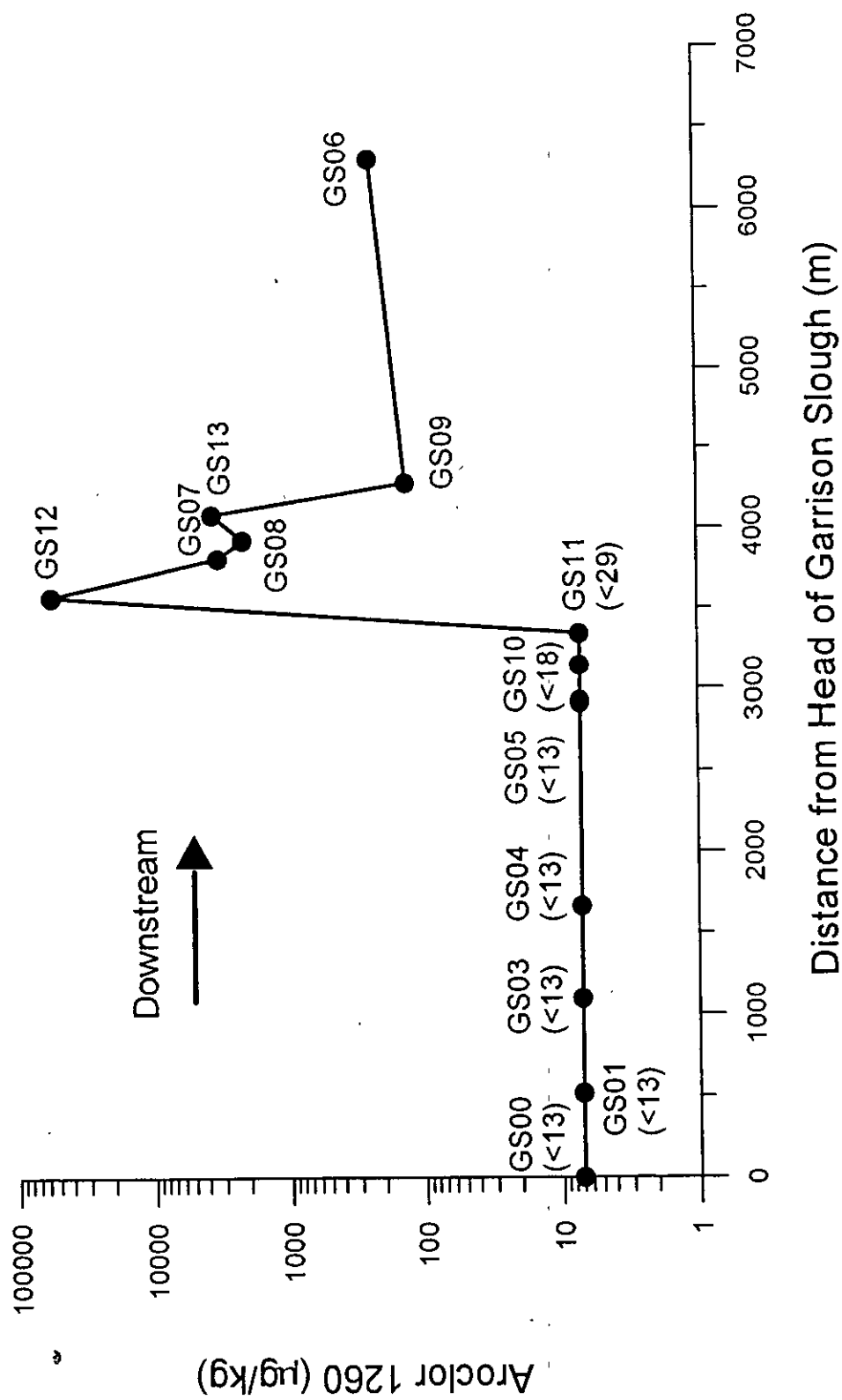


FIGURE 4.5. PCB Concentrations in Garrison Slough Sediment, 1994

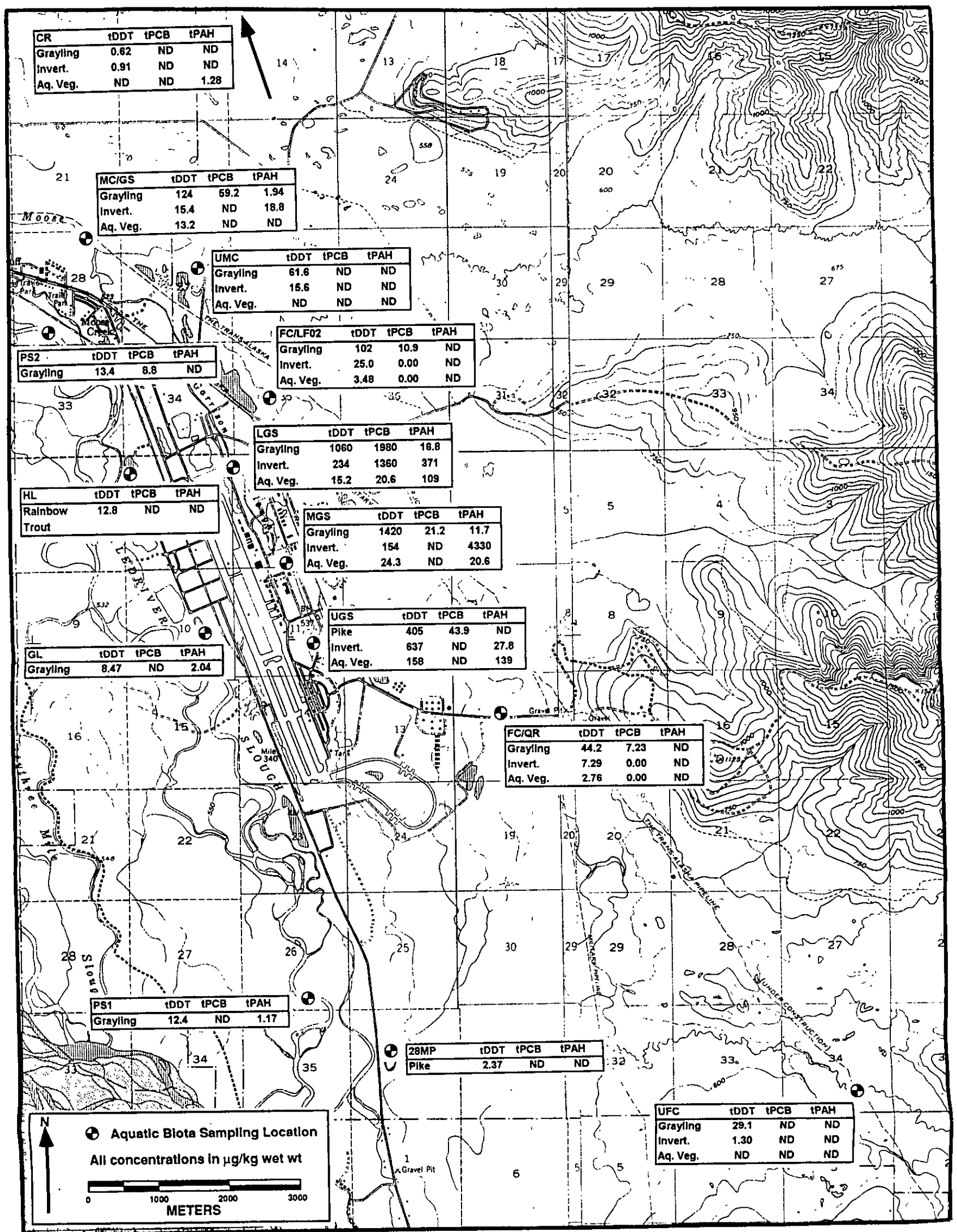


FIGURE 4.6. Total DDT, PCBs, and PAHs in 1994 Aquatic Biota Samples

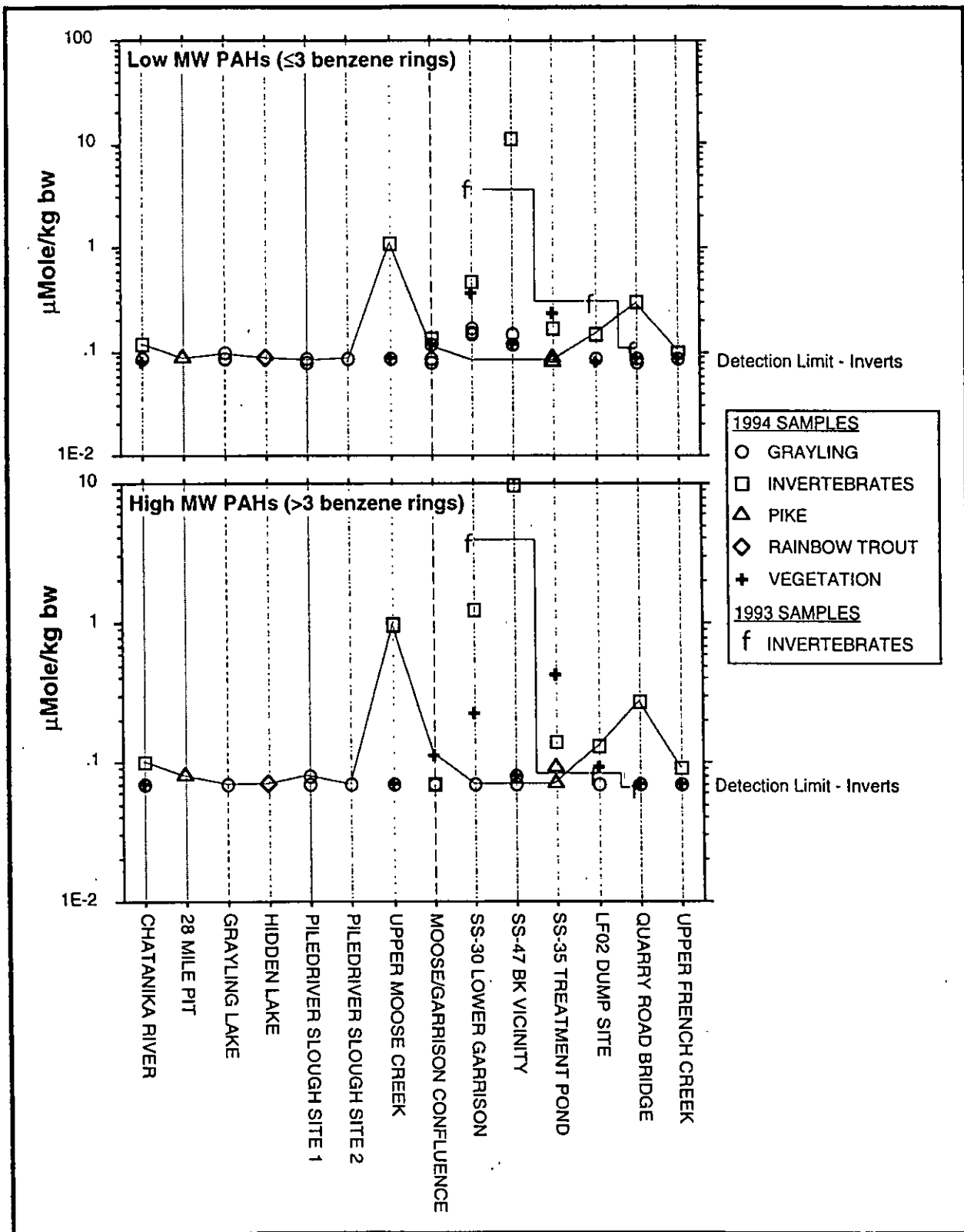


FIGURE 4.7. Scatterplot of PAHs in Aquatic Biota Samples

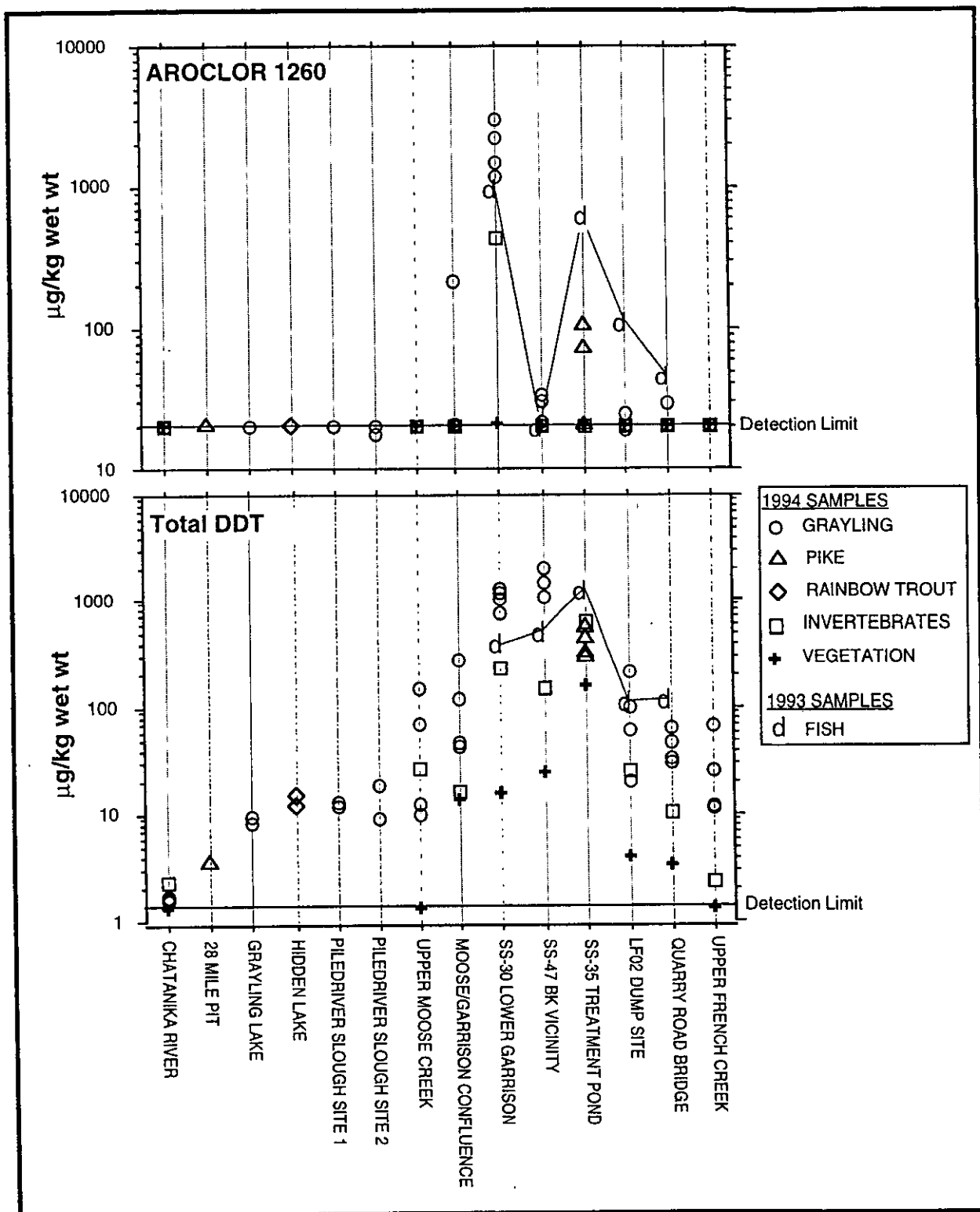


FIGURE 4.8. Scatterplot of PCBs and DDT in Aquatic Biota Samples

TABLE 4.1. Metals Concentrations in North Boundary Wells, 1992-1994 ^(a)					
Parameter	Concentration Range (µg/L)				
	1992	1993	1994	Background	MCL
Antimony	all 200 U	all 69.4 U	1.0 U - 3.9	1.0 U - 200 U	6
Arsenic	5 U ^(a) - 31	3.0 - 31	3.0 U - 37	1.0 U - 63	50
Barium	60 - 290	58 - 420	56 - 498	35 - 420	2000
Beryllium	all 3 U	all 0.814 U	all 2.0 U	0.814 U - 3.0 U	4
Cadmium	all 10 U	4.7 U - 6.6 U	1.0 U - 1.3	1.0 U - 10 U	5
Chromium	20 U - 31	5.42 U - 9.0	1.4 - 18	5.42 U - 46	100
Copper	all 20 U	2.65 U - 6.1	6.2 - 109	2.65 U - 140	1000 ^(c)
Iron	30 U - 15000	84 - 8000	569 - 22100	100 - 33000	300 ^(c)
Lead	5 U - 7.6	0.6 U - 2.0	1.0 U - 22	0.6 U - 48	15 ^(d)
Manganese	1100 - 11000	1000 - 12000	1300 - 8930	20 - 6500	50 ^(c)
Nickel	30 U - 32	17.9 U - 18	5.1 - 41.5	5.0 - 77	1000 ^(a)
Silver	all 20 U	all 2.87 U	all 1.0 U	1.0 U - 20 U	100 ^(c)
Vanadium	all 30 U	3.84 U - 7.4	1.4 - 31	3.84 U - 52	NA ^(f)
Zinc	10 U - 43 U	3.44 U - 11	9.0 - 91	3.44 U - 120	5000 ^(c)

(a) Wells 51MB1, 51MB3, 51MB4, 51MB5, 08M01.

(b) U Not detected at or above the given concentration.

(c) Secondary MCL.

(d) Action level.

(e) Federal MCL remanded in 1994.

(f) NA Not applicable.

TABLE 4.2. Arsenic in Samples from Wells 11-4 and 18-8		
Date Sampled	Concentration ($\mu\text{g/L}$)	
	Well 11-4	Well 18-8
August 1991 ^(a)	60 S ^(b)	73.4
June 1993	21	18
August 1993	37	18
Background range	1.0 U to 63	

(a) Reported in USAF 1993d.

(b) S Reported value was determined by the Method of Standard Additions.

TABLE 4.3. BTEX and Lead in Samples from OU-2 Source Areas							
Well	Year	Concentration (µg/L)					
		Benzene	Ethyl-benzene	Toluene	Xylenes	Total Lead	Dissolved Lead
10MW12	1994	10.6	0.20 U ^(a)	0.33	0.40 U	NA ^(b)	NA
11-3	1991 ^(c)	1 J ^(d)	5 U	5 U	5 U	3.3	NA
	1993	0.105 U	0.22	0.26	1.8	NA	NA
	1994	1.0 U	1.0 U	1.0 U	1.0 U	NA	NA
18-3	1991	5 U	3 J	5 U	8	1 U	NA
	1993	0.105 U	9.1	1.2	61	NA	NA
	1994	1.0 U	1.0 U	1.0 U	1.0 U	NA	NA
19-2A	1991	20 J	390	1500	2300	NA	NA
	1992	11	610	1900	4000	NA	NA
19MW07	1994	1.04	0.28	0.30 U	0.40 U	NA	NA
19MW06	1992	5 U	5 U	5 U	5 U	3 U	NA
	1993	0.105 U	0.046 U	0.056 U	0.202 U	NA	NA
	1994	1.0 U	1.0 U	1.0 U	1.0 U	NA	NA
26-1	1991	510	1100	3000	6300 D ^(e)	334	NA
	1993	780	1200	7000	9800	420	99
26-6	1991	2 J	5 U	5 U	1 J	1 U	NA
	1993	0.39	0.046 U	0.16 U	0.202 U	NA	NA
	1994	1.0 U	1.0 U	1.0 U	1.0 U	NA	NA
26-8	1991	1400	610	4200	5400	795	NA
	1993	2700	990	8500	9100	690	55
26-13	1991	5 U	5 U	5 U	5 U	3.2	NA
	1992	2 U	2 U	2 U	2 U	NA	NA
	1993	0.17	0.14	0.13 U	0.56	NA	NA
26MW19	1994	0.20 U	0.20 U	0.38	0.40 U	NA	NA
MCL		5	700	1000	10,000	15 ^(f)	NA

(a) U Not detected at or above the given concentration.

(b) NA Not applicable.

(c) 1991 data reported in USAF 1993d.

(d) J Analyte detected below the method detection limit, but above the instrument detection limit.

(e) D Sample was diluted.

(f) Action level.

TABLE 4.4. Metals in Samples from Source Areas LF03, LF05, and LF06; 1993 Sitewide Monitoring Program

Analyte	Concentration (µg/L)												MCL
	03M01				05M01								
	1988 ^(a)	Aug-92 ^(b)	Jun-93	Aug-93	05M01	06M04	06M05	Background		Maximum			
				Aug-93	Aug-93	Aug-93	Minimum						
Antimony	76	200 U ^(c)	69.4 U	69.4 U	69.4 U	69.4 U	69.4 U	1.0 U	200 U	6			
Arsenic	65	NA ^(d)	3	32	4.4	3.5	12	1.0 U	63	50			
Barium	15,300	1100	970	1200	110	150	120	35	420	2000			
Beryllium	34	3 U	0.814 U	1.1	1.91	1.9	0.87	0.814 U	3.0 U	4			
Cadmium	88	10 U	4.70 U	4.70 U	4.70 U	4.70 U	4.70 U	1.0 U	10 U	5			
Chromium	1890	20 U	5.42 U	9.2	5.42 U	5.42 U	5.42 U	5.42 U	46	100			
Cobalt	632	20 U	4.05 U	4.05 U	4.05 U	4.05 U	4.4	4.05 U	31	NA			
Copper	5440	20 U	2.65 U	9.7	2.65 U	4.0	2.65 U	2.65 U	140	1000 ^(e)			
Iron	1,180,000	32,000	38,000	46,000	970	160	3900	100	33,000	300 ^(d)			
Lead	1130	NA	2	NA	0.88 U	1.4 U	4.0	0.6 U	48	15 ^(f)			
Manganese	16,900	920	900	890	2800	1600	1400	20	6500	50 ^(g)			
Nickel	1470	30 U	17.9 U	20	17.9 U	17.9 U	17.9 U	5.0	77	100 ^(g)			
Silver	NA	20 U	4.3	2.87 U	2.87 U	2.87 U	2.87 U	1.0 U	20 U	100 ^(h)			
Vanadium	2430	30 U	3.84 U	14	3.84 U	4.1	3.84 U	3.84 U	52	NA			
Zinc	18,400	110	44	170	3.44 U	3.44 U	3.44 U	3.44 U	120	5000 ^(h)			

(a) Data reported in HLA 1989.

(b) Data reported in USAF 1993a.

(c) U Not detected at or above the given concentration.

(d) NA Not applicable.

(e) Secondary MCL.

(f) Action level.

(g) Federal MCL remanded by EPA.

TABLE 4.5. VOCs Detected in Samples from OU and SER Wells, 1994 SWMP ^(a)							
Well	Concentration (µg/L)						
	Trans-1,2-DCE	1,1,1-Trichloroethane	1,2-Dichloroethane	TCE	Tetrachloroethene	Benzene	Toluene
49M05	1.0 U	1.0 U	0.50 U	5.8	0.50 U	3.8	1.0 U
45M04	1.0 U	1.0 U	0.50 U	4.7	0.50 U	1.0 U	1.0 U
45MW07	1.0 U	1.0 U	1.2	2.0	0.84	1.0 U	1.0 U
36-1	1.0 U	3.1	0.50 U	0.50 U	0.70	1.0 U	1.0 U
36-2	1.0 U	3.0	0.50 U	0.60	0.50 U	1.0 U	1.0 U
36M03	1.0 U	2.7	0.50 U	0.50 U	0.50 U	1.0 U	1.1
04M07	10 U	10 U	5.0 U	5.0 U	5.0 U	10 U	290
38M01	100 U	100 U	50 U	50 U	50 U	400	100 U
38SLW	1.0 U	1.0 U	0.65	0.50 U	0.50 U	20	1.0 U
16-2	1.0 U	2.3	0.50 U	0.65	0.50 U	1.0 U	1.8
47M01	1.8	1.0 U	0.50 U	0.50 U	0.50 U	1.0 U	1.0 U
47M05	1.4	1.0 U	0.50 U	0.50 U	0.50 U	1.0 U	1.0 U
MCL	100	200	5	5	5	5	1000

(a) Data for OU-2 wells are reported in Table 4.3.

(b) U Not detected at or above the given concentration.

TABLE 4.6. Recent and Historical TCE Concentrations at WP45		
Well	Date	TCE ($\mu\text{g/L}$)
45M04	Jun-92	2.6
	Aug-92	4.0
	Aug-94	4.7
	Sep-94	6.3
45MW07	Jun-92	NA ^(a)
	Aug-92	2.0
	Aug-94	2.0
	Sep-94	3.0

(a) NA Not available.

TABLE 4.7. DRO, GRO, and Lead in Samples from OU and SER Wells, 1994 SWMP				
Source Area	Well	DRO (mg/L)	GRO (mg/L)	Lead ^(a) ($\mu\text{g/L}$)
ST27	B-8	0.25 U ^(b)	0.25 U	54
	B-11	0.25 U	0.25 U	38
	B-19	0.25 U	0.25 U	40
SS39/SS63	39M01	0.30	0.25 U	1.6
	39M03	0.25 U	0.25 U	1.2
	39M04	0.25 U	0.25 U	1.0 U
	39M05	0.25 U	0.25 U	2.5
	53M02	0.25 U	0.25 U	2.8
LF04	04M02	0.38	0.25 U	28
	04M03	0.55	0.25 U	1.4
	04M04	1.30	0.25 U	1.0 U
	04M07	0.66	1.9	15
SS47	47M01	NA ^(c)	NA	16
	47M03	NA	NA	16
	47M05	NA	NA	5.2

(a) Background range of lead is 0.6 U to 48 $\mu\text{g/L}$.

TABLE 4.8. Metals in Samples from OU/SER Wells, 1994 SWMP

Well	Concentration (µg/L)													
	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chro- mium	Copper	Iron	Lead	Manga- nese	Nickel	Silver	Vena- dium	Zinc
36-1	1.0 U nd	32	202	2.0 U	1.0 U	12	28	13300	6.8	2270	15	1.0 U	11	32
36-2	1.0 U	16	270	2.0 U	1.0 U	3.3	2.4	6770	1.0 U	2710	5.8	1.0 U	2.1	14 U
36M03	1.0 U	33	144	2.0 U	1.0 U	1.5	2.0	5290	1.0 U	1860	4.1	1.0 U	1.6	17
04M02	1.0 U	78	790	2.0 U	1.0 U	14	9.5	140000 N	28	4600	70	1.0 U	61	30
04M03	1.0 U	200	600	2.0 U	1.0 U	9.4	4.6	200000	1.4	3800	53	1.0 U	12	34
04M04	1.0 U	81	270	2.0 U	1.0 U	15	11	90000	1.0 U	1700	53	1.0 U	23	37
04M07	1.0 U	51	380	2.0 U	1.0 U	26	46	65000	15	1600	54	1.0 U	39	98
38M01	1.0 U	3.0 U	9.6	1.0 U	1.0 U	1.4	6.2	560	3.1	65	8.8	1.0 U	1.0 U	67
38M02	1.0 U nd	24	1100	2.0	2.4	76	250	180000	89	3500	180	1.0 UN	93	260
38M03	1.0 UN	3.0 U	140	2.0 U	1.0 U	1.0 U	1.0 U	58	1.0 U	6.3	1.1	1.0 UN	1.0 UN	9.3
38M06	11	91	2400	4.8	2.3	670	650	330000	210	3200	970	3	400	980
38M16	1.0 U	100	970	2.0 U	1.0 U	48	100	180000	31	5200	95	1.0 U	75	160
38M17	1.0 UN	110	440	2.0 U	1.0 U	8.8	29	49000	7.9	4900	13	1.0 UN	28	62
38SLW	1.0 U	3.0 U	74	2.0 U	1.0 U	1.6	7.3	4900	2.8	81	2.5	1.0 U	1.0 U	400
01M04	1.8	13	310	1.0 U	1.9	22	130	35000	50	660	39	1.0 U	40	120
05M01	1.0 U	7.3	100	1.0 U	1.0 U	1.2	2.6	1200	1.4	2500	4.1	1.0 U	1.0 U	22
Birch Lake	1.0 U	43	18	1.0 U	1.0 U	1.8	9.7	680	1.0 U	950	3.3	1.0 U	1.0 U	100

TABLE 4.8. Metals in Samples from OU/SER Wells, 1994 SWMP

Well	Concentration (µg/L)													
	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Nickel	Silver	Vanadium	Zinc
Min. Back-ground	1.0 U	1.0 U	35	0.814 U	1.0 U	5.42 U	2.65 U	100	0.6 U	20	5.0	1.0 U	3.84 U	3.44 U
Max. Back-ground	200 U	63	420	3.0 U	10 U	46	140	33000	48	6500	77	20 U	52	120
MCL	6	50	2000	4	5	100	1000 ^(a)	300 ^(d)	15 ^(d)	50 ^(a)	100 ^(a)	100 ^(d)	NA	5000 ^(a)

(a) U Not detected at or above the given concentration.

(b) N Matrix spike recovery exceeded acceptance limits.

(c) Secondary MCL.

(d) Action level.

(e) Federal MCL remanded by EPA in 1995.

TABLE 4.9. Source Areas Adjacent to Garrison Slough			
Source Area	Source Area Name	Wastes Received and Releases	Category
LF03	Base landfill (inactive)	General refuse; landfill received waste oils, spent solvents, paint residues and thinners, radioactive photographic chemicals; POL wastes burned during fire training	OU-5
FT08	Fire training area (past)	Suspected fire training area; POL waste used in fire training exercises	SER
FT09	Fire training area (present)	500 to 1000 gallons of JP-4 fuel used during each exercise	OU-5
ST11	Fuel-saturated area	Diesel fuel floating on water table; possibly released from pipeline	OU-2
SS12	JP-4 spill, Building 2351	JP-4 fuel spill; 5000 gallons spilled, majority contained within building, 100 gallons flowed outside building	SER
ST20	Refueling loop fuel-saturated area	JP-4 fuel spills in the refueling area; also leaks of JP-4 fuel from delivery lines from buried storage tanks	OU-1
DP26	E-10 fuel tank sludge burial pit	Fuel in weathered sludge from periodic fuel storage tank cleaning, buried in pit. Leaks from fuel storage facility	OU-4
WP32	Sewage treatment plant spill	Ponds provide additional contact time for chlorination of primary treated effluent; also serve as diversion ponds for POL spills; major spill of unknown industrial chemical or solvent in 1975	SER
WP33	Treated effluent infiltration pond	Infiltration pond receives treated effluent from wastewater treatment plant year-round	OU-4
WP34	Sewage sludge drying beds	Discharge of digested sludge from industrial wastewater; may contain industrial contaminants such as heavy metals	(not FFA)
SS35	Asphalt mixing area	Mixing area for asphalt and base for road oiling operation; commingled waste oils and solvents mixed with contaminated fuels; possible disposal of 200 empty asphalt drums at site	OU-4
SS37	Drum storage, asphalt mixing area	Mixing area for asphalt and staging area for road oiling; possible leaks from tank containing tar and asphalt emulsion, waste oils and contaminated fuel; drums of waste oil, diesel fuel, JP-4 and PD-680	OU-4
SS47	Commissary parking lot fuel spill	Fuel-contaminated soil in parking lot found at a depth of 9 feet in 1987; parking lot covers 150,000 square feet	SER
ST49	Building 1300 LUST spill site	Diesel fuel for generator discharged through floor drains in combat alert hangar complex to septic system leach field	OU-1
WP60	New auto hobby shop	Water from oil/water separator drains to leach field; oils overwhelm leach field	SER

TABLE 4.10. Summary of Sample Results for July 1992 Garrison Slough Sample Event, BES Monitoring ^(a)								
Location	Water			Sediment				
	VOCs (µg/L)	Nitrate (mg/L)	SVOCs (µg/L)	TCLP Metals (mg/L)	SVOCs (mg/kg)	Organophos- phorus pesticides (mg/kg)	Organochlorine pesticides/PCBs (mg/kg)	
	502.2/524.2	353.2	625.0	40 CFR 268	8270	8140	8080	
GS-1: Transmitter Rd.	ND ^(b)	ND	ND	Barium 1.8	Di-n-butyl- phthalate 0.932 bis(2-ethylhexyl)- phthalate 0.509	ND	ND	
GS-2: Flightline Ave. runoff	ND	ND	ND	Arsenic 0.11 Barium 0.83	Di-n-butyl- phthalate 0.426	ND	ND	
GS-3: Arctic Ave.	ND	ND	ND	Arsenic 0.14 Barium 2.0	Di-n-butyl- phthalate 0.713 bis(2-ethylhexyl)- phthalate 0.217	ND	ND	
GS-4: Central Ave.	ND	ND	ND	Arsenic 0.02 Barium 1.8	Di-n-butyl- phthalate 0.501 Fluoranthene 0.521	ND	ND	
GS-5: Quarry Rd.	Benzene 2.6 ^(c) cis-1,2-DCE 2.2	ND	ND	Arsenic 0.37 Barium 1.1	ND	ND	ND	
GS-6: Fire Training Area	ND	ND	ND	Arsenic 0.0081	Di-n-butyl- phthalate 0.209	ND	4,4'-DDD 0.476 4,4'-DDE 0.039 4,4'-DDT 3.89	
GS-7: French Creek and Quarry Rd.	ND	0.15	ND	ND	Di-n-butyl- phthalate 0.884	ND		
Detection Limits	1.0	0.1	10	0.002 - 1.0	0.200	0.05 - 2.0	Pest. - 1.0 ^(d) PCB - 10	

(a) Data provided by Bioenvironmental Engineering Services, Eielson AFB.

(b) ND Not detected.

(c) Duplicate sample showed 2.6 µg/L benzene and 2.1 µg/L DCE.

(d) Methoxychlor and toxaphene - 10 mg/kg.

TABLE 4.11. VOCs Detected in Surface Water Samples from Garrison Slough, BES Monitoring ^(a)						
Sample Location	Date	Concentration (µg/L)				
		Benzene	Toluene	Ethylbenzene	TCE	1,2-DCE
ST49 Combat Alert Center	28-Apr-93	0.2	ND ^(b)	ND	ND	ND
	15-Jun-93	ND	1.8	ND	ND	ND
GS-6 Fire Training Area	29-Apr-92	2.9	ND	ND	0.8	ND
	22-Sep-92	2.2	ND	ND	0.7	ND
	28-Apr-93	0.2	ND	ND	ND	ND
	15-Jun-93	ND	0.8	ND	ND	ND
GS-5 Quarry Rd.	01-Jul-92	ND	ND	0.3	0.4	2.2
	28-Apr-93	2.6	ND	ND	ND	ND
	15-Jun-93	2.2	ND	ND	ND	ND
	08-Sep-93	1.8	ND	ND	ND	ND
GS-4 Central Ave.	22-Sep-93	2.2	ND	ND	0.7	ND
	29-Apr-92	0.5	ND	ND	0.2	ND
	28-Apr-93	0.4	ND	ND	ND	ND
	08-Sep-93	ND	ND	ND	ND	ND
GS-1 Transmitter Rd.	29-Apr-92	0.3	ND	ND	ND	ND
	28-Apr-93	ND	ND	ND	ND	ND

(a) Data provided by Bioenvironmental Engineering Services, Eielson AFB. All analyses by Method 503.1 except July 1992 data (Method 502.2/524.2).

(b) ND Not detected. Detection limits range from 0.2 µg/L to 0.5 µg/L.

TABLE 4.12. Surface Water and Sediment Sample Summary, Previous Investigations

Surface Water Body	Sampling Location	Reference	Media Sampled- Analytical Parameters
IRP Source Area Investigations: WP32, SS35, SS42, WP60, LF01, LF02			
Garrison Slough	32S02	HLA 1989	Surface water-V ^(a) , SV ^(b) , M ^(c) , TPH ^(d) , CN ^(e) , TDS ^(f) , CA ^(g) Sediment-V, SV, M, TPH
Garrison Slough	32S03	HLA 1991	Surface water-purgeable halocarbons, nitrogen
Garrison Slough	32S04	HLA 1991	Surface water-purgeable halocarbons, nitrogen
Garrison Slough	35S01	HLA 1989	Surface water-V, SV, CN, TDS Sediment-V, PP ^(h) , M, TPH
Garrison Slough	42S01	HLA 1989	Surface water-V, SV, TPH, CN, TDS, CA Sediment-V, SV, TPH, CN
Garrison Slough	60S01	HLA 1989	Sediment-V, SV, TPH, lead
Garrison Slough	60S03	HLA 1991	Surface water-V, SV, lead Sediment-V, SV, TPH, lead
Garrison Slough	60S04	HLA 1991	Surface water-V, SV, lead Sediment-V, SV, TPH, lead
Garrison Slough	60S05	HLA 1991	Surface water-V, SV, lead Sediment-V, SV, TPH, lead
Piledriver Slough	01S01	HLA 1989	Surface water-V, SV, M, TPH, TDS, CA Sediment-V, SV, TPH
French Creek	02S01	HLA 1989	Surface water-V, SV, M, TPH, TDS, CA Sediment-V, SV, TPH
IRP Garrison Slough Investigation			
Garrison Slough	62S01	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S02	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S03	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S04	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S05	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S06	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S07	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S08	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M

TABLE 4.12. Surface Water and Sediment Sample Summary, Previous Investigations			
Surface Water Body	Sampling Location	Reference	Media Sampled- Analytical Parameters
Garrison Slough	62S09	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S10	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
Garrison Slough	62S11	HLA 1991	Surface water-V, SV, PP, TPH, M, CA Sediment-V, SV, PP, TPH, M
OU-2 Remedial Investigation			
Spruce (Hardfill) Lake	Spruce (Hardfill) Lake	USAF 1993d	Surface water-V, SV, TPH, PP, M, TDS, CA, TOC ⁽ⁱ⁾ Sediment-SV, M, TPH, CA, TOC

- (a) V Volatile organics.
- (b) SV Semivolatile organics.
- (c) M Metals.
- (d) TPH Total petroleum hydrocarbons.
- (e) CN Cyanide.
- (f) TDS Total dissolved solids.
- (g) CA Common anions.
- (h) PP Pesticides and PCBs.
- (i) TOC Total organic carbon.

TABLE 4.13. Compounds Detected in Garrison Slough Water Samples, IRP Source Area Investigations							
Reference	Concentration (µg/L)						
	HLA 1989			HLA 1991			
Compound	32S02	35S01	42S01	60S03	60S04	60S05	
Benzene	ND ^(a)	2.55	0.39	0.26	0.26	ND	ND
Chloromethane	10.9	ND	ND	ND	ND	ND	ND
Total 1,2-dichloroethane	ND	ND	0.745	0.62	0.56	0.52	
Trichloroethene	ND	0.781	1.43	1.06	0.97	0.81	
Bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	2.3	
Trichlorofluoromethane	ND	ND	ND	ND	ND	0.41	

(a) ND Not detected.

**TABLE 4.14. Compounds Detected in Garrison Slough Sediment Samples,
IRP Source Area Investigations^(a)**

Compound	Concentration (mg/kg dry wt)			
	32S02S1	35S01S1	60S01S1	42S01S1
Methylene chloride	2.3	ND ^(b)	ND	ND
Chlorodane	NA ^(c)	0.012	NA	NA
DDD	NA	0.422	NA	NA
DDE	NA	0.107	NA	NA
DDT	NA	0.097	NA	NA
Hydrocarbons, petroleum	5,390	793	96.0	419
Barium	169	183	NA	NA
Cadmium	1.13	ND	NA	NA
Chromium	23.7	21.3	NA	NA
Copper	36.8	33.0	NA	NA
Iron	24,300	24,000	NA	NA
Lead	23.6	ND	17.3	NA
Manganese	395	900	NA	NA
Nickel	24.6	24.9	NA	NA
Zinc	121	73.4	NA	NA

- (a) All data from HLA 1989.
 (b) ND Not detected.
 (c) NA Not analyzed.

TABLE 4.15. Surface Water Results Summary, IRP Garrison Slough Investigation^(a)

Chemical Name	No. of Detections	Average of Detected Values ($\mu\text{g/L}$)	Maximum Value Detected ($\mu\text{g/L}$)	Location of Maximum
Total Metals				
Arsenic	1	695	695	62S02
Barium	11	296	1,800	62S02
Beryllium	2	19	36.3	62S02
Cadmium	1	3.8	3.8	62S02
Copper	2	39.5	60.6	62S02
Iron	11	43,700	438,000	62S02
Lead	1	91.1	91.1	62S02
Manganese	11	2,960	18,500	62S02
Nickel	2	43.2	75.3	62S02
Thallium	1	1,120	1,120	62S02
Zinc	11	54.9	46.7	62S02
Pesticides and PCBs				
DDD	8	0.0439	0.108	62S03
DDE	1	0.006	0.006	62S02
Volatile Organics				
trans-1,2-Dichloroethene	4	0.31	0.46	62S07
Trichloroethene	2	0.720	0.840	62S07
Vinyl chloride	1	0.35	0.35	62S03
Benzene	5	2.05	7.10	62S03
Toluene ^(b)	2	0.75	1.14	62S02
Semivolatile Organics				
4-methylphenol	1	2.5	2.5	62S02

(a) Data from HLA 1991.

(b) Trip blank showed 0.47 $\mu\text{g/l}$ of toluene; therefore, the concentrations detected in the environmental samples may not represent actual field conditions.

TABLE 4.16. Sediment Results Summary, IRP Garrison Slough Investigation ^(a)				
Compound	No. of Detections	Average of Detected Values (mg/kg dry wt)	Maximum Detected Value (mg/kg dry wt)	Location of Maximum
Metals				
Arsenic	11/11	77.8	264	62S08
Barium	11/11	278	535	62S08
Cadmium	7/11	1.21	2.37	62S11
Chromium	6/11	9.65	14.3	62S06
Copper	11/11	25.6	49.5	62S11
Iron	11/11	44,960	78,300	62S08
Lead	9/11	47.8	123	62S06
Manganese	11/11	1,400	3,140	62S11
Nickel	11/11	16.1	20.3	62S04
Zinc	11/11	97.8	209	62S11
Pesticides and PCBs				
Chlordane	9/11	0.296	0.862	62S09
DDD	11/11	7.66	58.6	62S04
DDE	11/11	0.439	2.05	62S04
DDT	11/11	6.32	62.4	62S04
PCB-1260	6/11	1.50	7.65	62S08
Volatile Organics - none detected				
Semivolatile Organics - none detected				
Other				
Petroleum hydrocarbons	11/11	819	1,920	62S11

(a) All data from HLA 1991.

TABLE 4.17. Total Metals Detected in 1993 Surface Water Samples

Water Body	Station	Concentration (µg/L)												Zinc
		Anti-mony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Nickel	Silver	Vanadium
Garrison Slough	GS00	69.4 U ^(a)	13	210	0.814 U	6.5 U	5.42 U	2.65 U	7600	0.91	1900	17.9 U	2.87 U	3.84 U
	GS01	69.4 U	14	180	0.814 U	6.5 U	5.42 U	2.65 U	6300	0.60 U	1300	17.9 U	2.87 U	3.84 U
	GS02	69.4 U	17	200	0.814 U	6.9 U	5.42 U	2.65 U	8200	0.75	1700	17.9 U	2.87 U	3.84 U
	GS03	69.4 U	14	190	0.814 U	7.8 U	5.42 U	2.65 U	7100	0.62	1700	17.9 U	2.87 U	3.84 U
	GS04	69.4 U	7.3	120	0.814 U	5.4 U	5.42 U	2.65 U	710	0.60 U	510	17.9 U	2.87 U	3.84 U
	GS05	69.4 U	14	120	0.814 U	6.1 U	5.42 U	2.65 U	2100	0.60 U	650	17.9 U	2.87 U	3.84 U
French Creek	GS06	69.4 U	5.4	100	0.814 U	6.1 U	5.42 U	2.65 U	850	0.60 U	220	17.9 U	2.87 U	3.84 U
	FCBG ^(b)	69.4 U	2.1	30	0.814 U	4.70 U	6.1	3.8	2400	0.75	110	17.9 U	2.87 U	7.8
	FC01	69.4 U	4.7	47	0.814 U	4.70 U	5.42 U	2.65 U	2700	0.60 U	220	17.9 U	2.87 U	3.84 U
	FC02	69.4 U	4.9	37	0.814 U	4.70 U	5.42 U	2.65 U	3300	0.69	180	17.9 U	2.87 U	3.84 U
Moose Creek	FC03	69.4 U	5.9	44	0.814 U	6.3 U	5.42 U	2.65 U	2900	0.79	160	17.9 U	2.9	3.84 U
	MC01	69.4 U	5.8	42	1.4	4.70 U	5.42 U	2.65 U	4100	1.0 U	260	17.9 U	2.87 U	7.5
	PS01	69.4 U	2.0 U	46	1.2	4.70 U	5.42 U	2.65 U	67	1.2 U	21	17.9 U	2.87 U	3.84 U
Piledriver Slough	FP01	69.4 U	6.2	76	0.814 U	6.2 U	5.42 U	2.65 U	280	0.60 U	160	17.9 U	2.87 U	3.84 U
	LL01	69.4 U	2.0	13 U	0.814 U	4.70 U	5.42 U	2.65 U	620	0.60 U	33	17.9 U	2.87 U	3.84 U
Lakes/ Ponds		69.4 U	2.0	35	0.814 U	1.0 U	5.42 U	2.65 U	100	0.6 U	20	5.0	1.0 U	3.84 U
	Min. background ^(c)	1.0 U	1.0 U											
	Mean background	200 U	11	130	3.0 U	10 U	20 U	20 U	4400	5 U	1900	30 U	20 U	30 U
	Max. background	200 U	63	420	3.0 U	10 U	46	140	33000	48	6500	77	20 U	52

(a) U Not detected at or above the given concentration.

(b) Background values for French Creek.

(c) Background values for groundwater.

TABLE 4.18. Metals Detected in 1993 Sediment Samples

Water Body	Station	Concentration (mg/kg dry wt)								
		Arsenic	Barium	Chromium	Copper	Iron	Lead	Manganese	Nickel	Zinc
Garrison Slough	GS00	3.4	400	8.0	11	7100	3.1	81	7.6	21
	GS01	21	69	6.8	8.3	19000	9.1	150	5.6	45
	GS02	33	68	5.4	5.2	27000	6.6	370	2.6	27
	GS03	26	75	4.2	2.9	19000	2.2	280	2.3 U ^(a)	17
	GS04	18	130	4.6	5.6	14000	5.3	2800	2.7	26
	GS05	9.8	1500	41	30	16000	64	440	29	17
French Creek	GS06	70	180	5.1	4.6	26000	4.7	990	2.5	24
	FCBG	3.4	94	17	13	12000	4.7	140	14	35
	FC01	7.9	62	10	10	14000	3.2	190	8.8	25
	FC02	29	120	13	9.7	31000	3.0	350	9.7	30
	FC03	18	110	13	12	19000	4.3	280	10	30
	MC01	23	84	13	8.9	16000	3.6	270	10	30
Moose Creek										
Piledriver Slough	PS01	3.9	61	14	17	13000	4.7	180	14	36
Lakes/ Ponds	FP01	18	20	2.5	4.4	4700	3.1	500	3.5	8.7
	LL01	3.7	76	13	14	9000	4.6	84	12	33
Background Soil Concentrations ^(b)										
Minimum		<1.9	39	6.3	8.3	5660	2.3	89	8.4	15
Mean		12	296	23	37	22568	8.8	352	28	57
Maximum		47	1260	61	99	54100	23	936	67	139

(a) U Not detected at or above the given concentration.

(b) Includes values for sand and gravel fill, floodplain soil, and loess.

TABLE 4.19. VOCs Detected in Surface Water Samples							
Station	Year	Concentration (µg/L)					
		Benzene	cis-1,2-DCE	Ethylbenzene	Tetrachloro-ethylene	TCE	Dichloro-difluoro-methane
GS00	1993	0.62	0.24	0.046 U ^(a)	0.049 U	0.065 U	NA ^(b)
	1994	1.0 U	NA	1.0 U	0.50 U	0.50 U	2.5
GS01	1993	1.8	1.4	0.046 U	0.049 U	0.38	NA
	1994	1.0 U	NA	1.0 U	0.50 U	0.61	1.0 U
GS02	1993	0.96	0.75	0.046 U	0.049 U	0.21	NA
GS03	1993	0.93	0.84	0.046 U	0.049 U	0.20	NA
GS05	1993	0.105 U	0.20	0.086	0.049 U	0.30	NA
	1994	1.0 U	NA	1.0 U	0.50 U	0.75	1.0 U
GS06	1993	0.105 U	0.127 U	0.063	0.049 U	0.075	NA
FCO2	1993	0.105 U	0.127 U	0.046 U	0.049 U	0.065 U	NA
PS01	1993	0.105 U	0.127 U	0.046 U	0.071	0.065 U	NA

(a) U Not detected at or above the given concentration.

(b) NA Not analyzed.

TABLE 4.20. DRO Detected in 1993 Sediment Samples	
Station	DRO (mg/kg dry wt)
GS01	26
GS02	38
GS03	22
GS06	14
FC03	11
MC01	12
FP01	41
LL01	11

TABLE 4.21. Pesticides Detected in Surface Water Samples		
Sample	Concentration ($\mu\text{g/L}$)	
	4,4'-DDD	4,4'-DDE
1994 - None detected		
Detection Limit	0.1 U ^(a)	0.1 U
1993		
GS00	0.022	0.0009 U
GS01	0.052	0.0018
GS02	0.033	0.0012
GS03	0.034	0.0035
GS04	0.011	0.0009 U
GS05	0.0071	0.00098
GS06	0.0075	0.0009 U
FC02	0.0013	0.0009 U
FC03	0.00085	0.0009 U
1990 (HLA 1991)		
62S01	0.010	0.006 U
62S02	0.026	0.006
62S03	0.108	0.006 U
62S04	0.074	0.006 U
62S05	0.050	0.006 U
62S06	0.033	0.006 U
62S07	NA	0.006 U
62S08	NA	0.006 U
62S09	NA	0.006 U
62S10	0.023	0.006 U
62S11	0.027	0.006 U

(a) U Not detected at or above the given concentration.

TABLE 4.22. Pesticides and PCBs Detected in Sediment Samples

Station	Concentration ($\mu\text{g/kg}$ dry wt)			
	4,4'-DDD	4,4'-DDT	4,4'-DDE	Aroclor 1260
1994				
GS00	71	13 J ^(a)	3.3 U ^(b)	13 U
GS01	11000	3600 J	340	13 U
GS03	8600	4200 J	540	13 U
GS04	130	39 J	12	13 U
GS05	22	8.2 J	3.3 U	13 U
GS06	3.3 U	3.3 UJ	3.3 U	230
GS07	3.3 U	3.3 UJ	3.3 U	3200
GS08	3.3 U	3.3 UJ	3.3 U	2100
GS09	3.3 U	3.3 UJ	3.3 U	130
GS10	36	21	8.0	18 U
GS11	120	26	14	29 U
GS12	4.8 U	4.8 U	4.8 U	55000
GS13	15 U	15 U	15 U	3500
FC01	19	3.6 J	7.2	13 U
FC03	32	58 J	7.2	13 U
1993				
GS00	110	170	6.70 U	3.00 U
GS01	310	96	6.70 U	3.00 U
GS02	0.65 U	1.20 U	6.70 U	3.00 U
GS03	170	120	13	3.00 U
GS04	63	3.4	6.70 U	3.00 U
GS05	9.8	1.20 U	6.70 U	3.00 U
GS06	13	1.20 U	6.70 U	3.00 U
FC03	7.7	1.20 U	6.70 U	3.00 U
LL01	16	1.20 U	6.70 U	3.00 U
1990 (HLA 1991)				
62S01	57	67	16	14 U
62S02	234	13	62	84 U
62S03	1730	2500	118	19 U
62S04	58600	62400	2050	19 U

TABLE 4.22. Pesticides and PCBs Detected in Sediment Samples				
Station	Concentration ($\mu\text{g/kg}$ dry wt)			
	4,4'-DDD	4,4'-DDT	4,4'-DDE	Aroclor 1260
62S05	15200	848	1760	22 U
62S06	190	22	29	57
62S07	825	629	77	25
62S08	577	721	54	7650
62S09	244	124	43	652
62S10	5180	1340	460	226
62S11	1460	839	163	404

(a) J Estimated concentration.

(b) U Not detected at or above the given concentration.

TABLE 4.23. Semivolatile Organic Compounds in 1993 Sediment Samples			
Analyte	Concentration ($\mu\text{g/kg}$ dry wt)		
	MC01	FP01	LL01
Anthracene	177 U ^(a)	370	210
Benzo[a]anthracene	170 U	650	170 U
Benzo[b]fluoranthene	176 U	680	176 U
Benzo[k]fluoranthene	248 U	730	248 U
Benzo[g,h,i]perylene	216 U	400	216 U
Benzo[a]pyrene	164 U	670	164 U
Chrysene	184 U	960	240
Diethylphthalate	460	133 U	133 U
Fluoranthene	212 U	2300	1300
Phenanthrene	185 U	1300	980
Pyrene	177 U	2600	1400

(a) U Not detected at or above the given concentration.

TABLE 4.24. Low-Molecular-Weight PAHs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration (µg/kg wet wt)							
		Naptha- lene	Acenaph- thylene	Acenaph- thene	Fluorene	Phenan- threne	Anthra- cene	Fluor- anthene	Pyrene
Background/Reference									
CR	Aquatic Vegetation	1.83 U ^a	0.71 U	1.28	1.21 U	2.51 U	2.19 U	5.26 U	4.48 U
MC/GS	Fish 4, Grayling	1.86 U	0.73 U	4.12	3.63	2.56 U	2.24 U	5.36 U	4.57 U
MC/GS	Invertebrate	1.86 U	0.73 U	1.30 U	4.52	6.97	2.24 U	7.27	4.57 U
Garrison Slough									
UGS/SS35	Invertebrate	2.98 U	1.16 U	2.09 U	5.69	4.09 U	3.58 U	10.9	7.31 U
UGS/SS35	Aquatic Vegetation	1.86 U	0.73 U	1.30 U	3.20	15.3	2.24 U	21.8	18.1
MGS/SS47	Fish 1, Grayling	6.69	0.73 U	5.67	1.24 U	2.56 U	2.24 U	5.36 U	4.57 U
MGS/SS47	Fish 2, Grayling	1.86 U	0.73 U	8.52	1.24 U	5.08	2.24 U	5.36 U	4.57 U
MGS/SS47	Fish 3, Grayling	1.86 U	0.73 U	5.95	1.24 U	2.56 U	2.24 U	5.36 U	4.57 U
MGS/SS47	Fish 4, Grayling	1.86 U	0.73 U	7.71	5.09	2.56 U	2.24 U	5.36 U	4.57 U
MGS/SS47	Invertebrate	34.5	9.77	63.7	111	1050	132	742	540
MGS/SS47	Aquatic Vegetation	1.83 U	0.71 U	1.28 U	1.21 U	7.04	2.19 U	7.02	6.58
LGS/SS30	Fish 1, Grayling	1.86 U	0.73 U	9.53	1.24 U	4.73	2.24 U	5.36 U	4.57 U
LGS/SS30	Fish 2, Grayling	1.86 U	0.73 U	8.94	5.42	4.66	2.24 U	5.36 U	4.57 U
LGS/SS30	Fish 3, Grayling	1.83 U	0.71 U	11.1	5.46	2.51 U	2.19 U	5.26 U	4.48 U
LGS/SS30	Fish 4, Grayling	1.83 U	0.71 U	8.64	4.56	4.33	2.19 U	5.26 U	4.48 U
LGS/SS30	Invertebrate	2.98 U	1.16 U	6.69	7.85	29.1	3.58 U	36.8	41.4
LGS/SS30	Aquatic Vegetation	1.86 U	0.73 U	1.30 U	8.52	32.0	2.24 U	22.3	19.5

TABLE 4.24. Low-Molecular-Weight PAHs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration (µg/kg wet wt)							
		Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene
Offsite Monitoring									
PS1	Fish 2, Grayling	1.86 U	0.73 U	1.30 U	1.24 U	2.56 U	2.24 U	5.36 U	4.57 U
GL	Fish 2, Grayling	1.86 U	0.73 U	1.30 U	4.08	2.56 U	2.24 U	5.36 U	4.57 U

(a) U Not detected at or above the given concentration.

TABLE 4.25. High-Molecular-Weight PAHs Detected In 1994 Aquatic Biota Samples

Location	Description	Concentration (µg/kg wet wt)							
		Benzo(a)- anthra- cene	Chrysene	Benzo(b)- fluor- anthene	Benzo(k)- fluor- anthene	Benzo(a)- pyrene	Indeno- (1,2,3-cd) pyrene	Dibenzo- (a,h) anthracene	Benzo- (g,h,i) perylene
Background/Reference									
CR	Aquatic Vegetation	1.07 U ^(a)	2.22 U	1.61 U	1.64 U	1.46 U	1.73 U	1.24 U	1.37 U
MC/GS	Fish 4, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
MC/GS	Invertebrate	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
Garrison Slough									
UGS/SS35	Invertebrate	1.75 U	4.95	2.62 U	2.67 U	2.39 U	6.22	2.02 U	2.24 U
UGS/SS35	Aquatic Vegetation	8.27	11.6	17.3	8.21	10.1	11.8	3.21	9.77
MGS/SS47	Fish 1, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
MGS/SS47	Fish 2, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	2.23	1.76 U	1.26 U	1.40 U
MGS/SS47	Fish 3, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
MGS/SS47	Fish 4, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
MGS/SS47	Invertebrate	247	296	345	141	241	187	39	150
MGS/SS47	Aquatic Vegetation	1.07 U	2.22 U	1.61 U	1.64 U	1.46 U	1.73 U	1.24 U	1.37 U
LGS/SS30	Fish 1, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
LGS/SS30	Fish 2, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U
LGS/SS30	Fish 3, Grayling	1.07 U	2.22 U	1.61 U	1.64 U	1.46 U	1.73 U	1.24 U	1.37 U
LGS/SS30	Fish 4, Grayling	1.07 U	2.22 U	1.61 U	1.64 U	1.46 U	1.73 U	1.24 U	1.37 U
LGS/SS30	Invertebrate	20.8	50.3	63.2	25.2	32.8	27.3	7.43	21.8
LGS/SS30	Aquatic Vegetation	5.39	4.2	6.1	1.67 U	3.22	3.88	1.26 U	3.7

TABLE 4.25. High-Molecular-Weight PAHs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration (µg/kg wet wt)							
		Benzo(a)- anthra- cene	Chrysene	Benzo(b)- fluor- anthene	Benzo(k)- fluor- anthene	Benzo(a)- pyrene	Indeno- (1,2,3-cd) pyrene	Dibenzo- (a,h) anthracene	Benzo- (g,h,i) perylene
Offsite Monitoring									
PS1	Fish 2, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	2.33	1.76 U	1.26 U	1.40 U
GL	Fish 2, Grayling	1.09 U	2.27 U	1.64 U	1.67 U	1.49 U	1.76 U	1.26 U	1.40 U

(a) U Not detected at or above the given concentration.

TABLE 4.26. Pesticides and PCBs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration (µg/kg wet wt)					Aroclor 1260
		4,4'-DDE	2,4'-DDD	2,4'-DDT	4,4'-DDD	4',4-DDT	
Background/Reference							
CR	Fish 1, Grayling	0.53	0.25 U ^(a)	0.18 U	0.26 U	0.15 U	20.0 U
CR	Fish 2, Grayling	0.49	0.25 U	0.18 U	0.26 U	0.15 U	20.0 U
CR	Fish 3, Grayling	0.60	0.25 U	0.18 U	0.26 U	0.15 U	20.0 U
CR	Fish 4, Grayling	0.53	0.25 U	0.18 U	0.33	0.15 U	20.0 U
CR	Invertebrate	0.26 U	0.34 U	0.24 U	0.91	0.21 U	20.0 U
UFC	Fish 1, Grayling	12.7	0.25 U	0.18 U	5.87	6.65	20.0 U
UFC	Fish 2, Grayling	7.32	0.28	0.51	1.46	1.54	20.0 U
UFC	Fish 3, Grayling	9.10	9.91	0.18 U	46.1	3.55	20.0 U
UFC	Fish 4, Grayling	6.77	0.25 U	0.18 U	3.39	1.44	20.0 U
UFC	Invertebrate	0.31	0.28 U	0.20 U	0.29 U	0.99	20.0 U
UMC	Fish 1, Grayling	33.8	13.3	0.18 U	73.5	34.2	20.0 U
UMC	Fish 2, Grayling	14.6	1.36	2.37	18.8	33.0	20.0 U
UMC	Fish 3, Grayling	5.94	0.25 U	0.18 U	4.29	1.66	20.0 U
UMC	Fish 4, Grayling	3.11	0.71	0.60	3.27	2.03	20.0 U
UMC	Invertebrate	5.41	3.34 U	2.36 U	10.2	1.99 U	20.0 U
MC/GS	Fish 1, Grayling	71.0	20.0	0.18 U	196	0.15 U	216
MC/GS	Fish 2, Grayling	16.1	2.68	0.18 U	23.4	0.92	20.0 U
MC/GS	Fish 3, Grayling	12.1	4.21	0.17 U	28.5	2.56	20.0 U
MC/GS	Fish 4, Grayling	39.5	12.6	0.18 U	38.7	28.3	20.6
MC/GS	Invertebrate	3.28	0.25 U	0.18 U	12.1	0.15 U	20.0 U

TABLE 4.26. Pesticides and PCBs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration ($\mu\text{g/kg}$ wet wt)					
		4,4'-DDE	2,4'-DDD	2,4'-DDT	4,4'-DDD	4'-4-DDT	Aroclor 1260
MC/GS	Aquatic Vegetation	2.04	1.75	0.25 U	6.90	2.54	20.0 U
Garrison Slough							
UGS/SS35	Fish 1, Pike	82.2	82.8	0.18 U	244	26.8	104
UGS/SS35	Fish 2, Pike	52.0	67.6	0.18 U	186	16.5	20.0 U
UGS/SS35	Fish 3, Pike	77.7	118	0.18 U	345	21.7	20.0 U
UGS/SS35	Fish 4, Pike	56.9	38.9	0.18 U	181	23.7	71.4
UGS/SS35	Invertebrate	73.7	105	0.29 U	422	36.5	20.0 U
UGS/SS35	Aquatic Vegetation	7.50	47.4	0.18 U	85.3	17.7	20.0 U
MGS/SS47	Fish 1, Grayling	95.4	182	0.18 U	780	26.2	20.0 U
MGS/SS47	Fish 2, Grayling	179	361	0.18 U	1450	50.7	21.8
MGS/SS47	Fish 3, Grayling	174	203	0.18 U	1050	52.6	30.2
MGS/SS47	Fish 4, Grayling	108	152	0.18 U	781	27.7	32.8
MGS/SS47	Invertebrate	19.0	25.2	0.29 U	71.7	38.5	20.0 U
MGS/SS47	Aquatic Vegetation	1.88	4.30	0.18 U	15.4	2.68	20.0 U
LGS/SS30	Fish 1, Grayling	73.4	109	0.18 U	560	0.15 U	1180
LGS/SS30	Fish 2, Grayling	133	174	0.18 U	989	0.15 U	3000
LGS/SS30	Fish 3, Grayling	124	125	0.18 U	782	0.15 U	2240
LGS/SS30	Fish 4, Grayling	234	139	0.18 U	813	0.15 U	1500
LGS/SS30	Invertebrate	18.4	90.0	0.3 U	105	20.1	437
LGS/SS30	Aquatic Vegetation	1.82	3.04	0.19 U	10.3	0.15 U	20.6

TABLE 4.26. Pesticides and PCBs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration (µg/kg wet wt)					Aroclor 1260
		4,4'-DDE	2,4'-DDD	2,4'-DDT	4,4'-DDD	4,4'-DDT	
French Creek							
FC/QR	Fish 1, Grayling	17.9	15.6	0.18 U	32.5	0.15 U	28.9
FC/QR	Fish 2, Grayling	16.2	0.25 U	0.18 U	13.9	2.59	20.0 U
FC/QR	Fish 3, Grayling	12.6	2.25	0.18 U	11.2	4.18	20.0 U
FC/QR	Fish 4, Grayling	15.4	4.93	0.18 U	21.1	6.26	20.0 U
FC/QR	Invertebrate	1.83	0.92 U	0.65 U	5.46	0.55 U	20.0 U
FC/QR	Aquatic Vegetation	0.97	0.41	0.18 U	1.38	0.15 U	20.0 U
FC/LF02	Fish 1, Grayling	50.6	13.3	37.0	42.3	78.6	24.6
FC/LF02	Fish 2, Grayling	7.58	1.40	2.00	4.70	4.70	20.0 U
FC/LF02	Fish 3, Grayling	14.1	6.02	8.32	17.6	15.0	20.0 U
FC/LF02	Fish 4, Grayling	19.6	11.7	0.18 U	68.4	3.54	18.8 J ^(b)
FC/LF02	Invertebrate	4.20	0.47 U	6.41	5.21	9.18	20.0 U
FC/LF02	Aquatic Vegetation	0.89	0.25 U	0.37	1.03	1.19	20.0 U
Offsite Monitoring							
PS1	Fish 1, Grayling	7.98	0.25 U	0.27	2.23	1.08	20.0 U
PS1	Fish 2, Grayling	7.77	0.30	0.70	2.41	1.98	20.0 U
PS2	Fish 1, Grayling	4.59	0.25 U	0.18 U	2.99	0.88	20.0 U
PS2	Fish 2, Grayling	11.0	0.25 U	0.18 U	5.72	1.66	17.6 J
28MP	Fish 1, Pike	2.37	0.25 U	0.18 U	0.26 U	0.15 U	20.0 U
GL	Fish 1, Grayling	6.24	0.25 U	0.18 U	1.95	0.15 U	20.0 U
GL	Fish 2, Grayling	5.77	0.25 U	0.18 U	1.31	0.36	20.0 U

TABLE 4.26. Pesticides and PCBs Detected in 1994 Aquatic Biota Samples

Location	Description	Concentration ($\mu\text{g/kg}$ wet wt)				
		4,4'-DDE	2,4'-DDD	2,4'-DDT	4,4'-DDD	4'-4-DDT
HL	Fish 1, Rainbow Trout	9.13	0.25 U	0.18 U	1.39	1.05
HL	Fish 2, Rainbow Trout	12.1	0.25 U	0.18 U	1.56	0.45
						20.0 U
						20.0 U

(a) U Not detected at or above the given concentration.

(b) J Estimated concentration.

5.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

SARA requires that remedial actions at Superfund sites achieve a cleanup level that protects human health and the environment. In addition, cleanups must attain "legally applicable or relevant and appropriate" requirements (ARARs), which are promulgated under federal or state law, unless a waiver is warranted.

Nonpromulgated advisories or guidance are referred to as "to-be-considered" criteria (TBCs) that may also be incorporated into the evaluation of potential remedies. Superfund remedies are not required to meet TBCs, but they may be used in the selection of remedies in the absence of applicable or sufficiently protective ARARs.

There are three general types of ARARs: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs are usually health- or risk-based concentration limits for specific hazardous substances in various environmental media (e.g., water and soils). Location-specific ARARs impose restrictions on certain types of activities, based on site characteristics. Action-specific ARARs are requirements triggered by the type of remedial activities under consideration. Federal and state environmental laws often do not neatly fall into one category.

The sitewide RI has identified contaminants in surface water, sediment, and aquatic biota at Eielson AFB. The nature and magnitude of the risks to human health and the environment from the contaminants were evaluated as part of the sitewide biological and human health baseline risk assessments.

Potential chemical- and location-specific ARARs for any sitewide remedial action are discussed below. Potential action-specific ARARs are identified in the sitewide FS because they are dictated by the type of remedial action under consideration (USAF 1995c).

5.1 CHEMICAL-SPECIFIC REQUIREMENTS

Chemical-specific ARARs for groundwater, surface water, and petroleum-contaminated soils have been identified for Eielson AFB. These criteria are discussed below.

5.1.1 Groundwater Protection

At Eielson AFB, the aquifer system is used as a drinking water supply. Drinking water standards apply to the point of use and not to the aquifer; however, federal (40 CFR 141) and state (18 AAC 80) drinking water standards may be considered relevant and appropriate to the aquifer. Federal and state drinking water standards are listed in Table 5.1. The only MCLs that are typically exceeded in groundwater at Eielson AFB are those for manganese and iron, which are secondary standards. As discussed in Section 3.6, high manganese and iron concentrations are typical of background conditions for Eielson AFB and the Fairbanks area.

Groundwater is protected in accordance with the Alaska Water Quality Standards (18 AAC 70). Groundwater is protected for Class (1)(A), Water Supply. Standards for toxic and deleterious substances, petroleum hydrocarbons, and oil and grease are identified in Table 5.2.

5.1.2 Surface Water

Section 304 of the Clean Water Act required EPA to establish criteria for water quality that will lead to the protection of human health and aquatic life. These criteria were derived from the evaluation of the latest scientific knowledge on the kind and extent of all identifiable effects of a contaminant in water, including effects on invertebrates, fish, wildlife, and plant life.

The EPA ambient water quality criteria (AWQC) for contaminants identified in surface water during the sitewide RI are listed in Table 5.1. Table 5.1 also includes the highest surface water concentrations measured at Eielson AFB in 1993 and 1994. Arsenic and manganese exceeded the human health criteria at all locations except Piledriver Slough and Flightline Pond, and iron exceeded the freshwater chronic AWQC and human health criteria everywhere except at Piledriver Slough and Flightline Pond. As discussed previously, iron, manganese, and arsenic concentrations are typical of background conditions at Eielson AFB. The detection limits for some metals (antimony, cadmium, and silver) exceeded some of the AWQC. Concentrations of other metals were below AWQC.

Benzene slightly exceeded the value for the protection of human health (consumption of water and organisms) at one location (GS01) in one year (1993). Other VOCs were below AWQC. Where detected, the pesticides 4,4'-DDD and 4,4'-DDE exceeded the human health AWQC. 4,4'-DDD was detected at six Garrison Slough and two French Creek stations, and 4,4'-DDE was detected at four Garrison Slough stations (Table 4.21). Dieldrin exceeded the freshwater chronic AWQC and the human health criteria at FC02 in 1993. Dieldrin was not detected at this site in 1994 (at a detection limit of 0.1 µg/L).

The State of Alaska has promulgated water quality standards for specific classes of protected water use, and has adopted a nondegradation policy for waters of higher quality than the criteria (18 AAC 70). The Alaska water quality standards that pertain to the contaminants of concern identified in surface water at Eielson AFB are listed in Table 5.2. Surface waters at Eielson AFB are protected for Classes (1)(A) Water Supply, (1)(B) Water Recreation, and (1)(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife. For most classes of water use, concentrations of toxic and deleterious substances may not exceed Alaska drinking water standards, or where those standards do not exist, EPA water quality criteria (Table 5.1). Surface waters at Eielson AFB do not exceed drinking water standards with the exception of iron and manganese (both secondary standards). EPA human health water quality criteria are exceeded for 4,4'-DDD (Garrison Slough and French Creek), 4,4'-DDE (Garrison Slough), and dieldrin (French Creek). The criteria for petroleum hydrocarbons, oil and grease for all classes of water use in Garrison Slough are violated at some locations, where a visible sheen is present on the water.

5.1.3 Sediment

No chemical-specific ARARs for the contaminants of concern in freshwater sediment currently exist. The State of Alaska has established cleanup standards for leaks and spills of petroleum products from storage tanks. These standards are also used by ADEC as numeric guidance for the cleanup of petroleum products from other types of releases (18 AAC 75). The guidance includes numeric soil cleanup target levels for diesel range hydrocarbons (100 mg/kg) and gasoline range hydrocarbons (100 mg/kg), benzene (0.1 mg/kg) and BTEX (10 mg/kg). The highest concentration of petroleum hydrocarbons detected in sediment at Eielson AFB in 1993 and 1994 was 41 mg/kg diesel range hydrocarbons in Flightline Pond, which is well below ADEC's target cleanup level.

5.1.4 Fish

There are no chemical-specific ARARs for the contaminants of concern in aquatic biota. The Food and Drug Administration's (FDA) action levels for the marketability of fish can be a TBC for the protection of human health. These levels are used as guidance to determine whether contaminated food should be removed from the marketplace. Sport fishing is common on Eielson AFB.

The action level for total DDT in fish tissue for human consumption is 5 mg/kg wet weight (FDA Guideline 7420.08, 1978). The highest fish tissue total DDT concentration was about 2 mg/kg wet weight (Table 4.26). There is no action level for PCBs or any PAH. The FDA, however, has established a temporary tolerance level for PCB residues in food for human consumption until these contaminants are eliminated from the environment (21 CFR 109.30). The temporary tolerance level for PCB residues in the edible portion of fish and shellfish is 2 mg/kg wet weight. PCBs in two grayling caught in lower Garrison Slough exceeded this level, at 2.4 mg/kg and 3.0 mg/kg.

5.2 LOCATION-SPECIFIC REQUIREMENTS

The location-specific requirements below can apply to any action taken to remediate contaminated fish or sediments. These requirements will be addressed further in the sitewide FS.

5.2.1 Floodplain or Stream

For activities on a floodplain, action must be taken to avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values (40 CFR 6, Appendix A). Eielson AFB is located on the floodplain of the Tanana River.

Under the Fish and Wildlife Coordination Act, if any activity requires diversion, channeling, or other modification of a stream or river and affects fish or wildlife, action must be taken to protect the fish or wildlife (40 CFR 6.302).

5.2.2 Wetlands

Designated wetlands are protected under the Clean Water Act. Any remedial activities conducted in wetland areas must be implemented in a manner that avoids adverse effects, minimizes potential harm, and preserves and enhances the wetlands to the extent possible. Although permit requirements are waived under CERCLA, excavation or fill would require special planning and could require wetland replacement if a significant area were affected.

TABLE 5.1. Water Quality Criteria and Standards

Contaminant	Maximum Concentration (µg/L)	Location, Year	Concentration (µg/L)				
			Freshwater Aquatic Life Criteria ^(a)		Human Health, 10 ⁻⁶ Risk for Carcinogens ^(a)		Drinking Water Standard (MCL ^(b))
			Acute	Chronic	Water and Organisms	Organisms only	
Antimony	<69.4	NA	NA ^(c)	NA	14	4300	6
Arsenic	17	GS02, 1993	360 (As III)	190 (As III)	0.018	0.14	50
Barium	210	GS00, 1993	NA	NA	2000 (MCL)	NA	2000
Beryllium	1.4	MC01, 1993	NA	NA	W ^(d)	W	4.0
Cadmium	<4.7	NA	1.79	0.66	W	W	5.0
Chromium	6.1	FCBG, 1993	984 (Cr III) 16 (Cr VI)	117 (Cr III) 11 (Cr VI)	W	W	100
Copper	3.8	FCBG, 1993	9.22	6.54	1300	NA	1300 ^(e) 1000 SMCL ^(b)
Iron	8200	GS02, 1993	NA	1000	300 (SMCL)	NA	300 SMCL
Lead	0.91	GS00, 1993	33.78	1.32	W	W	15 ^(e)
Manganese	1900	GS00, 1993	NA	NA	50 (SMCL)	100 (marine)	50 SMCL
Nickel	<17.9	NA	789	87.71	610	4600	100 ^(e)
Silver	2.9	FC03, 1993	1.23	NA	NA	NA	100 SMCL
Zinc	8.7	GS05, 1993	65.04	58.91	NA	NA	5000 SMCL
Benzene	1.8	GS01, 1993	NA	NA	1.2	71	5.0
TCE	0.75	GS05, 1994	NA	NA	2.7	81	5.0
Tetrachloroethylene	0.071	PS01, 1993	NA	NA	0.8	8.85	5.0

TABLE 5.1. Water Quality Criteria and Standards

Contaminant	Maximum Concentration (µg/L)	Location, Year	Concentration (µg/L)				Drinking Water Standard (MCL ^(b))
			Freshwater Aquatic Life Criteria ^(a)		Human Health, 10 ⁻⁶ Risk for Carcinogens ^(a)		
			Acute	Chronic	Water and Organisms	Organisms only	
Dieldrin	0.026	FC02, 1993	2.5	0.0019	0.00014	0.00014	NA
4,4'-DDD	0.052	GS01, 1993	NA	NA	0.00083	0.00084	NA
4,4'-DDE	0.0035	GS03, 1993	NA	NA	0.00059	0.00059	NA

(a) EPA Region IV Toxic Substance Spreadsheet, January 1995.

(b) MCL Maximum Contaminant Level, federal (40 CFR 141) and state (18 AAC 80) drinking water standards.

(c) NA Not applicable.

(d) W Criteria withdrawn in National Toxics Rule.

(e) Action level; concentration allowable in not more than 10% of the samples.

(f) SMCL Secondary MCL.

(g) MCL for nickel remanded by EPA in February 1995.

TABLE 5.2. Alaska Water Quality Standards

(1) Fresh Water Uses	Toxic and Other Deleterious Organic and Inorganic Substances	Petroleum Hydrocarbons, Oils and Grease
(A) Water Supply (i) drinking, culinary, and food processing	Substances may not exceed Alaska Drinking Water Standards (18 AAC 80) or, where those standards do not exist, EPA <i>Quality Criteria for Water</i> .	May not cause a visible sheen upon the surface of the water. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.
(A) Water Supply (iii) agriculture, including irrigation and stock watering	Same as (1)(A)(i) where contact with a product destined for human consumption is present. Same as (1)(C) or Federal Water Pollution Control Administration, <i>Water Quality Criteria</i> (WQC/FWPCA), as applicable to substances for stockwaters; concentrations for irrigation waters may not exceed WQC/FWPCA or WQC 11972.	May not cause a visible sheen upon the surface of the water.
(A) Water Supply (iii) aquaculture	Same as (1)(C).	Total aqueous hydrocarbons (TAQH) in the water column may not exceed 15 µg/l. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.
(A) Water Supply (iv) industrial	Substances that pose hazards to worker contact may not be present.	May not make the water unfit or unsafe for the use.
(B) Water Recreation (i) contact recreation	Same as (1)(A)(i).	May not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters must be virtually free from floating oils.
(B) Water Recreation (ii) secondary recreation	Substances that pose hazards to incidental human contact may not be present.	Same as (1)(B)(i)

TABLE 5.2. Alaska Water Quality Standards

(1) Fresh Water Uses	Toxic and Other Deleterious Organic and Inorganic Substances	Petroleum Hydrocarbons, Oils and Grease
(C) Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	<p>Individual substances may not exceed criteria in EPA, <i>Quality Criteria for Water</i> or, if those criteria do not exist, may not exceed the Primary Maximum Contaminant Levels of the Alaska Drinking Water Standards (18 AAC 80). If those criteria are absent, or if the department finds that the criteria are not appropriate for sensitive resident Alaskan species, the department will, in its discretion, establish in regulation chronic and acute criteria to protect sensitive and biologically important life stages of resident Alaskan species, using methods approved by EPA or alternate methods approved by the department. There may be no concentrations of toxic substances in water or in shoreline or bottom sediments, that, singly or in combination, cause, or reasonably can be expected to cause, toxic effects on aquatic life, except as authorized by this chapter. Substances may not be present in concentrations that individually or in combination impart undesirable odor or taste to fish or other aquatic organisms, as determined by either bioassay or organoleptic tests.</p>	Same as (1)(A)(iii)

(1) From 18 AAC 70, as amended by revisions that became effective on January 4, 1995.

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